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THE TRANSCASPIAN RAILWAY—COMPETITION: YESTERDAY AND TO-DAY.

THE TRANSCASPIAN RAILWAY—COMPETITION: YESTERDAY AND TO-DAY.

THE first European artist who has made the journey direct from the banks of the Caspian to Samarcand, by the railway constructed under the direction of Gen. Annenkoff, is the celebrated Russian painter Nicholas Karazine.

His name is not unknown to prominent persons who have followed with attention the literary and artistic movements of contemporary Europe. Nicholas Karazine was an officer of the Russian riflemen of Turkestan in the Eastern war of 1876 and 1877. He is a distinguished writer and painter, and is the author of a book entitled "Recollections of Central Asia," which has been translated into French, and of various notable pictures which have figured in the expositions of St. Petersburg and Moscow, among them "The Taking of Samarcand," exhibited in the present year in the academy of fine arts in the capital of Russia, and purchased a few weeks ago by the Emperor Alexander III.

He left St. Petersburg in June last, to assist in the festivities of the inauguration of the Transcaspian Railroad, and has reproduced with his pencil and brush the places and prospects of most interest on the line of the new road.

One of his original drawings is represented in the engraving which we herewith publish, under the title "Competition." The camel in the middle of the road, with its light burden, appears to be astonished at the form of the machine which advances along the rails with dizzy velocity and astounding noise. Yesterday and to-day! the past and the present in the desert of Kara Kum; the camel and the locomotive; the beast of burden and the machine; the caravan of dromedaries that journey slowly along and travel for many weeks the sandy plains, and the train of steam cars that fly over them rapidly in a few hours, conveying hundreds of tons of merchandise over that desolate desert, burning, shifting, without vegetation, opened by the work of Gen. Annenkoff to the civilizing influences of the Western world.—*La Ilustracion Espanola.*

THE NIEDRINGHAUS MEMORIAL BUILDING.

IN 1886, when Walter Niedringhaus, son of William F. Niedringhaus, secretary of the St. Louis Stamping Company, St. Louis, passed away in death, when just about to reach his majority, his bereaved father turned his thoughts to the erection of a fitting memorial. Prior to that time, Mr. Niedringhaus and his brother, Frederick G. Niedringhaus, had in contemplation the establishment of some place for the instruction and amusement of their one thousand employes, but the matter had not assumed definite shape in their minds. It was then that the thought came to Mr. W. F. Niedringhaus that a library and gymnasium, with a hall where entertainments and lectures could be given, in the neighborhood where his son's life work would have been, had he lived, and for the benefit of those employed in the establishment where he had spent much of his time, would be a most fitting memorial. In the carrying out of this idea, he was joined by Frederick G. Niedringhaus, and they entered upon the work with deep earnestness. To obtain an insight into the workings of a somewhat similar establishment, they visited the Stetson free gymnasium and library at Philadelphia. They found that there the results had been eminently satisfactory in every regard, but they saw further that to fully answer the purpose they had in view, they would have to shape their plans so as to embody a number of features wanting in the Stetson institution.

Their idea did not stop at free library and gymnasium. They realized that mere physical exercise and the use of a comfortable reading room with access to books, no matter how interesting, would, of themselves, lack the variety that always attracts. Therefore, they widened and extended the original idea, from time to time, as the suggestions came to them.

They were fortunate to find, on the northwest corner of Cass Avenue and Seventh Street, within three blocks from their works, a piece of ground perfectly adapted to the purpose, and they at once took measures to secure it. A. Beinke, the architect, was instructed to prepare plans, the intention being to commence work in the spring or summer of 1887. But an annoying delay arose about this time. To secure a clear title to the land, it was found necessary to obtain a quit-claim deed from parties residing in France. It was not thought at first that this would be difficult, but they found many obstacles in their way, and it was not until about two months ago that the matter was satisfactorily settled, and then, although late in the building season, ground was broken at once, the contracts let for the erection of the building, and before this time next year the opening of the establishment to the public is counted upon.

The designs of the building indicate a most handsome structure, with the interior arrangements very convenient. It is to be of two stories, with a French gabled Mansard roof and an English basement, and have a frontage of 65 feet, with a depth of 110 feet, not including the gymnasium, which will be built as an addition. The plans call for a front of pressed brick, with stone trimmings, and wide stone steps to the main entrance. The windows are of the Gothic style of architecture and are numerous, being closely distributed over the front, and twenty to a side, so that the interior will be excellently lighted. Those in front will be of cathedral glass.

But it is in the convenience of the interior arrangements that the skill of the architect is most apparent. To the right of the main entrance is the directors' room, 15×30 feet. To the left of this is the library and reading room, 28×20 feet, both having high ceilings, with windows nearly all the way up from the floor. On each side of these rooms are wide stairs of gradual ascent leading to the gallery and basement. Back of them is the lecture room, 60×69 feet, of an elongated, semicircular shape. The floor is to be made in terraces, gently inclining toward the rear of the building, which is, in reality, the front of the hall, where the stage is located. The seats are to be arranged in tiers between five aisles, making in all four tiers of seats. An aisle runs around the wall from the side of one end of the stage to the other. There will also be proscenium boxes, and probably, also, gallery boxes. The stage is planned to occupy 25×18 feet. On each side of the stage are class rooms, each 12×17 feet, which can be utilized as dressing rooms in case of amateur theatricals or costume concerts. The lecture room is provided with seats for 1,300 people.

The second story is in reality a gallery, similar to the first gallery in any properly designed theater, and has a seating capacity of 400. The floor also inclines toward the front, so that as good a view of the stage can be obtained from the rear seats as from the front.

The front part of the basement is designed for the dining room. It is 50×81 feet, thoroughly lighted by English basement windows. In fact, as an ascent of seven feet will be required to reach the first floor, it will be but slightly below the surface of the street. The walls are to be wainscoted in rich woods, and the floor made of polished oak. In the rear is the kitchen, 22×18 feet, and along one side, adjoining the kitchen and dining room, is a bowling alley.

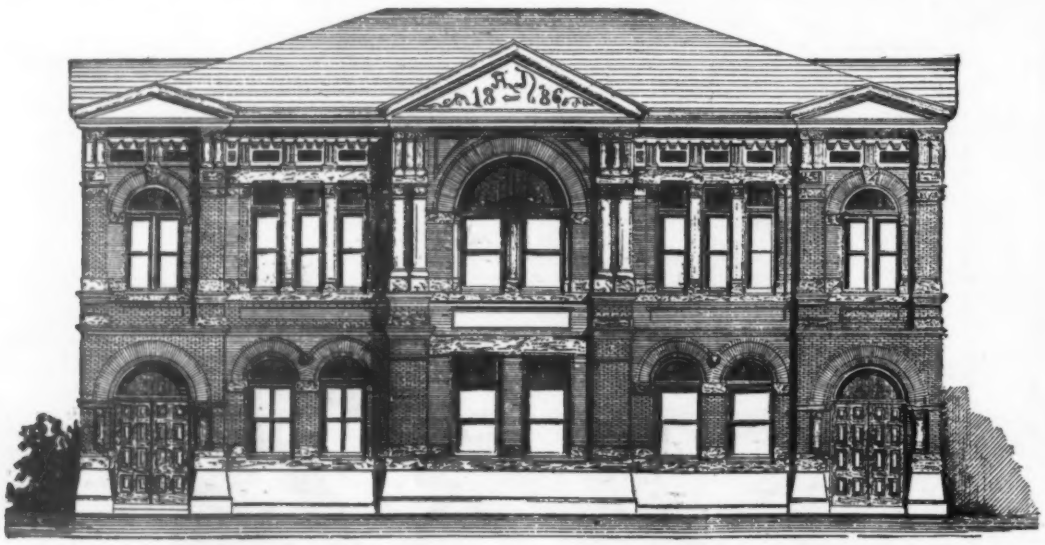
It is the idea to build the gymnasium as an addition, after the completion of the main building. The plans have not yet been prepared, but they will contemplate everything necessary to a thoroughly equipped gymnasium, containing horizontal, perpendicular and parallel bars, trapeze, dumb bells, Indian clubs, vaulting poles, rubber pulls, lifts, rowing apparatus, etc. But the part probably most appreciated in this department will be the baths, of which a sufficient number are to be supplied to enable several hundred persons to bathe each day.

The furnishing designed is in keeping with the building. The kitchen is to be provided with a complete hotel range, large enough to prepare edibles for several hundred people at one time. The sideboard, extending entirely across the side of the room, will contain the dishes, and a model arrangement of sinks is called for. The furniture of the dining room is to be plain and substantial, but not crowded, although from three hundred to four hundred people can be fed at one time. The furniture can be moved to the kitchen and the floor cleaned in a few minutes. The linen closet will be built in the wall. The directors' room is to be substantially fitted up with the furniture usual to such rooms. That of the library and reading room includes a handsome carpet and a good supply of reading tables and desks for writing. One side will have a file rack for newspapers and magazines; one, the office set aside for the librarian; and the other two, shelves for books.

The lecture room will be fitted up equal to any theater in the city. The seats are to be of the latest opera chair pattern, with folding backs and bottoms, with hat supports underneath, and the aisles carpeted. The walls will be papered in bright colors of modern, chaste pattern. The ceiling frescoing contemplated is not specially elaborate, that is, not glaring or gaudy, but the selections will be appropriate and the effect rare and pleasing. In the center will hang a large gas reflector with glass prisms that will, with the aid of side burners, light the room clearly and brightly. The stage footlights are of the usual order, and the space in front is large enough to accommodate a regular theater orchestra. Velvet-covered railings make the usual divisions of orchestra circle, parquet, and family circle. Rich curtain hangings are to be provided for the boxes. Eminent artists have in hand the painting of the stage scenery, which includes a wood, garden, yard, parlor, kitchen, cottage, winter and other scenes, and the properties are tables, chairs, arms, lamps, and every article necessary to reproduce scenes from natural life. The subject of the drop curtain is chaste and appropriate. In fact, the stage paraphernalia will cover everything required by any legitimate melodrama, spectacular production, comedy, or opera. The gallery is to be provided with the same kind of seats, only those in the center and directly opposite the stage will have smaller seats for the little folks.

The above is a fair description of the arrangement of the institution when completed. With the gymnasium and bath room annex, it will be the most complete and handsomest institution of the kind in this country, if not in the world, and will, no doubt, set an example that may, in course of time, be followed by other individual manufacturers or manufacturing companies. The total cost of the building and furnishings, exclusive of the library, will not fall short of twenty thousand dollars.

But what is of far greater importance than the structure itself is the multitudinous objects it is to be erected for, and the methods of carrying them into execution. In somewhat similar institutions, such as have been attempted on a small and incomplete scale, the interest displayed by those for whom they were founded has generally been spasmodic and uncertain, because of a lack of novel and changeable features. Generally, they have consisted merely of a gymnasium and reading room, and only those devoted to study or skill in physical exercise were persistent in attendance. As a rule, they offered no attractions equal to those of home to the women and girls, and consequently the married men seldom attended, as they did not feel justified in deserting the hearthstone for pleasures in which their wives and daughters could take no part. The Messrs. Niedringhaus, in their investigations, saw this, and in providing for it have done that which will make their



THE NIEDRINGHAUS MEMORIAL BUILDING, ST. LOUIS.

enterprise a success. The kitchen and dining room is naturally the women's field, although, of course, the institution is founded for them as much as for the men. Here they can give their socials and festivals. Should the wives of the members of any lodge desire to raise money for some commendable purpose, or should the ladies of North St. Louis have some charitable object in view that requires funds, these rooms will always be open to them for socials or festivals, and the proceeds, hence, be clear profit, as they will have nothing to pay for hall, heating, or light. Or should a social hop be given, the dining room floor could easily be cleared for the purpose. The concert hall, heated and lighted, is accessible for amateur theatricals and concerts in the same way. These amateur theatricals and concerts, especially in costume, will offer an ever varied and delightful attraction. They will call together the employes as well as the outsiders, and undoubtedly result in the formation of amateur societies which will offer attractions almost nightly. There are a large number of young ladies in the employ of the St. Louis Stamping Company, and they, with the wives and daughters of the workmen, will find in these directions an unlimited scope of profitable and happy work. The employes also have among themselves several societies, and the hall is to be opened for their meetings, rent free.

A series of lectures will be provided for the winter season by the directors, which will give the people an opportunity to hear some of the best known speakers in the country, whom they could never hear otherwise. The range of subjects is not limited, as they include social and political economy, science, religion, and humor, and especially on topics relating to invention and manufacture. Doubtless many prominent men of St. Louis will volunteer their services in this direction. There is no admission fee to be charged to these entertainments. On Sundays, a union Sunday school will be inaugurated, the song books, lesson leaves and pictorial charts to be furnished, and music made a prominent feature. On Sunday evenings, it is likely that there will be lectures on moral subjects, which, of course, will be purely non-sectarian.

The greatest care is to be exercised in the selection of

the library, and it will include treatises on all subjects, as well as fiction, history, travels, and biographies. Its doors are to be open to all, whether employes of the St. Louis Stamping Company or not, who are known to be worthy of the privilege. Books can be taken out for a limited period, say for ten days or two weeks, the borrower, of course, being responsible for loss or damage. As regards works on invention, machinery, construction, chemistry, and scientific subjects, it will be the most complete free library in the West, and selected with a view of making text books and treatises on these subjects accessible to all interested. Many of these books will be very rare and valuable, as the illustrations will form a large part of the contents. It is easy to foresee the beneficial results that will be effected by this feature. An interest must be created in the whys and wherefores of the details of manufacture, and the workman will no longer be content with the mere automatical knowledge of knowing how to do a thing; he will want to know the reasons back of it. Thus, even those who at first will take no interest in such study will become interested in the conversation of those who do, and ultimately lead them into studying the matter for themselves. In course of time if the interests of the workmen warrant it, an experimental workshop may be added.

The newspapers and magazines will include everything, from the daily papers to the literary, scientific, mechanical, and trade journals.

The management of the institution is to be in the hands of a board of directors in which the employes will have representation, and which will meet at least once a week to discuss measures and adopt plans for the pleasure and instruction of its beneficiaries.

While the institution is primarily for the employes of the St. Louis Stamping Company, it will be open to any well-behaved person, who can have the benefits of all its privileges, and will doubtless be warmly appreciated by all the people living in the vicinity. It will be absolutely free, there being no assessments for anything, and although the annual cost of maintaining it must involve heavy expenses, they will be borne entirely by William F. and Frederick G. Neidringhaus. —*Stoves and Hardware.*

[Continued from SUPPLEMENT, No. 671, page 10715.]

ON THE DISTRIBUTION OF INTERNAL FRICTION OF ENGINES.*

By ROBERT H. THURSTON, Ithaca, New York, Member of the Society.

DISTRIBUTION OF FRICTION.

Engine, Condenser, and Air Pump.—Diameter 21 inches, stroke 20 inches. This engine, 21"×20", in connection with an engine 12"×10" made a compound condensing engine which drove the Thomson-Houston dynamos used for the electric lighting of the city of Lansing. A complete test for friction, with change of load, had previously been made of these engines, separately and combined. This engine being larger than could be driven by power transmitted through the dynamometer, the plan was adopted of utilizing the connecting shaft between the high and low pressure engine, and of measuring the power necessary by indicator cards on the high pressure engine. Metallic paper and a fine brass point were used instead of the usual paper and pencil employed in taking indicator cards. Two dynamos were allowed to run light during the whole of this test, being driven by the high pressure engine; this friction being eliminated in the final result.

The method adopted was to take indicator cards of the high-pressure engine and the load to be carried throughout the test; then to add successively the main journals in the engine to be tested, the condenser and air pump, the connecting rod and crossheads, the valve and valve rod, and finally the piston and piston rod.

The plan was in great part successful, but could not be entirely carried out.†

Table VIII. shows the distribution of the friction in this series of trials.

TABLE VIII.

DISTRIBUTION OF FRICTION.

Condensing Engine.

21×20 inches, built by Lansing Iron and Engine Works.

Condition of Engine.	Symbol of Condition.	No. of Card.	Revolution per Minute.	Head Indicator. M. E. P.	Head Indicator. F. H. P.	Crank Indicator. M. E. P.	Crank Indicator. F. H. P.	Total Friction. H. P.	Average Friction. H. P.
High Pressure Engine and fixed load.	A	1	207	4·5	14·36	5·0	15·52	29·88	28·9
	A	2	207	4·5	14·36	4·0	12·42	26·78	
	A	3	207	4·75	15·16	4·75	14·74	29·90	
Main bearings of 30 × 34 engine coupled on.	B	4	205	4·5	14·23	6·25	19·21	33·44	35·2
	B	5	205	4·5	14·23	5·75	17·67	31·99	
	B	6	205	4·75	15·02	5·75	16·13	31·15	
Valve and Valve Rods connected to eccentrics.	C	7	204	4·75	18·56	7·5	28·50	47·06	42·5
	C	8	202	5·0	19·35	5·5	19·70	39·50	
	C	9	200	5·0	19·16	6·	22·36	41·52	
Air Pump and Condenser added.	D	10	198	5·0	19·27	8·5	31·35	50·62	48·6
	D	11	200	5·3	20·51	7·3	27·47	47·98	
	D	12	192	6·0	22·07	7·	25·04	47·11	
Connecting rod with crosshead and Piston added.	E	13	200	13·5	52·73	14·15	54·96	107·69	113·88
Air Pump Gauge with Pressure as shown subsequently.	E	14	172	17·5	57·08	18·5	59·28	116·96	
	E	15	172	18·	57·68	18·	59·32	117·00	
Average work shown by Vacuum Gauge.	F	....	.....	.....	.....	.....	.....	.. ..	63·80

* Presented at the eighteenth meeting, Scranton, 1888, American Society of Mechanical Engineers. Advance sheets from Vol. x. Transactions.

†A serious accident was barely escaped after the air pump had been attached and while the connecting rod was detached from the crank pin. The vacuum caused by the working of the air pump drew the connecting rod toward the rapidly revolving crank; the meeting of the two was heralded by a sudden and violent pounding. The rapidity of the motion prevented any serious damage, until the connecting rod could be safely put out of the way.

There were several conditions during this test that were not uniform throughout; nor were they normal. For instance, in cases C, D, and E, cards 7 to 15, the valve or piston of the engine or both was in motion, and it was impossible to lubricate the valve, although the piston was lubricated without difficulty. The results in both cases, C and D, can be considered as relative only, not absolute. Again, in case E, it was found impossible to prevent the action of the air pump on the piston; the work done was, however, shown by the vacuum gauge, and was equivalent, respectively, to a pressure of 9·82, 10·3, and 10·3 pounds, in cards 13, 14, and 15, or a work equivalent to 69·26, 61·12, and 61·12, with an average of 63·8 horse power over and above that due to moving the engine. The average of a large number of previous trials gave 7·13 H. P. as the total friction of this engine, together with air pump and condenser; and this fact must be noted in considering cases C and D.

Combining these various observations, we get the following results: Friction on main journals equals

$$B-A=3·3 \text{ H. P.}$$

Engine complete, air pump at work, case E, gives 113·88 H. P.; without piston, air pump, and unlubricated valves as before, gives us case D, 48·60 H. P. The difference, 65·28 H. P., includes work of air pump and friction of piston and rod. The work of air pump is 63·8 H. P., leaving for friction of piston and rod 1·48 H. P.

The difference between the total friction and that on the parts, already found, is the sum of the friction for cases C and D, which must be divided in the proportion indicated by the observations. Table IX. is a summary of the deductions from this set of trials of a condensing engine.

TABLE IX.

DISTRIBUTION OF FRICTION.

Condensing Engine, 21× 20 *inches.*

Summary of Results.

Parts of Engine Considered.	Conditions Combined Algebraically.	Friction—Horse Power.	Per cent. of Total Friction.
Main journals...	B—A	3·3	46·
Piston and rod, crosshead and pins	E—(D+F)	1·48	21·
Valve rod and eccentric.....	Determined as explained	1·47	21·
Air pump and condenser.....	" " "	0·88	12·
Total		7·13	10·

COEFFICIENT OF FRICTION. — The coefficient of friction can be deduced with certainty only for the main journals of the engine; since there is a variation in pressure of piston rings, stuffing boxes, and in angularity of the connecting rod, which is, at least to a great extent, unknown.

If we call f the coefficient of friction, p the pressure on the bearings in pounds for engines light, and plus mean pressure on piston for engines loaded, c the circumference of the bearings in feet, n the number of revolutions per minute, $f\ p\ c\ n$ will thus equal the "lost work" of friction, which has been determined in the previous experiments, and is expressed as horse power; this is indicated to foot pounds by multiplying by 33,000.

Hence $f\ c\ p\ n$=33,000 H. P.

$$f=\frac{33{,}000 \text{ H. P.}}{p.\ c.\ n.}$$

Table X. shows the value of this coefficient for the several engines tested, and Table XI. is a summary of *all* results.

TABLE X.

COEFFICIENT OF FRICTION FOR THE MAIN BEARINGS OF STEAM ENGINES.

Engine.	F. H. P. due to Main Journals.	Weight on Journals in Pounds.	Diameter of Journal in Inches.	Coefficient of Friction, Engine Light.	Coefficient of Friction, Engine Loaded.	Revolutions of Journal per Minute.
6"×12" Straight Line.....	0·85	1500	3	0·10	0·06	230
*12"×18" Automatic (L. I. W.).	3·70	2600	5	0·19	0·05	190
7"×10" Traction (L. I. W.).....	0·68	500	2¾	0·31	0·08	200
21"×20" Condensing (L. I. W.).....	3·30	4000	5½	0·09	0·04	206

* The 12"×18" automatic engine was new, and gave, throughout, an excessive amount of friction as compared with the older engines of the same class and make.

CONCLUSIONS AND DEDUCTIONS.

In each case the engine to be experimented with was first examined, by the process which has been so fully described in the preceding papers on this subject, to determine whether its friction under varying loads was actually constant, as in the engines previously tested. This was found to be practically the case in every instance, and even the compound engine, contrary to the expectation of the writer, exhibited substantially the same internal friction at all loads up to its full rated power, and with no load at all. The minimum friction was 13·5 H. P., the maximum 17·5, varying irregularly, with the character of the lubrication, probably, and giving the higher or the lower figure indifferently whatever the work done and however the power might be distributed between the two cylinders. As this engine was non-condensing, the problem still remains to be solved with respect to condensing engines, unless, indeed, the few experiments thus far reported may be taken, as is very probably the fact, as indicating the truth of the general principle of constancy of internal friction for all engines, whether condensing or non-condensing.

TABLE XI.

DISTRIBUTION OF FRICTION.

Summary of Results.

Parts of Engine.	Percentages of Total Friction. Straight Line 6 × 12, Balanced Valve.	Straight Line 6 × 12, Unbalanced Valve.	7" × 10" Lansing Iron Works—Traction Locomotive Valve Gear.	12" × 18" Lansing Iron Works — Automatic Balanced Valve.	21" × 20" Lansing Iron Works—Condensing Balanced Valve.
Main bearings.....	47·0	35·4	35·0	41·6	46·0
Piston and rod.....	32·9	25·0	21·0		
Crank pin.....	6·8	5·1	13·0	49·1	21·8
Crosshead and wrist pin.....	5·4	4·1			
Valve and rod	2·5	26·4	22·0	9·3	21·0
Eccentric strap.....	5·3	4·0			
Link and eccentric.....			9·0		
Air pump.....					12·0
Total...	100·0	100·0	100·0	100·0	100·0

These engines were also all tested to determine whether the previously reported increase of internal friction with speed was here to be accepted as correct. It was found that several engines differed somewhat in this respect, but that the variation was in all cases slight, and in some instances insensible or even reversed, the friction decreasing in one case, observably, with increasing speed. It was sufficiently evident, for all the engines here considered, that this variation was so unimportant as to be negligible. The figures given in the several tables which have been presented in the preceding pages are therefore to be accepted as not only correct and reliable, but also as not likely to be affected by construction or method of operation of engine to such an extent as to be inapplicable to steam engines generally. The writer, in the light of existing knowledge, would assume that it is the rule, with all the usual forms of engine, and under all common conditions of operation, that the internal friction of the machine is practically invariable with variation of useful work, and that it is very nearly independent of the speed of rotation and of piston, varying slightly, as a general rule, in the direction of increase with increase of speed. This latter principle leads to the conclusion that the friction coefficient of the rubbing surfaces decreases with the load on the engine and with increase of pressure on them—a result confirmed by numberless experiments of the writer and others, independently. With good lubrication, the coefficient of friction rapidly decreases with intensifying pressures, and to such an extent as to make the actual resistance to movement very nearly constant. It is now possible to study the reported data intelligently, and to deduce useful and reliable conclusions relative to the effect of these new facts upon the theory and upon the principles of designing and constructing as well as operating steam machinery.

The last table presented, summarizing the work of the whole research, gives in most readable and intelligible form the data and the laws which it has revealed. The most important item of friction waste, in every instance, is that of lost energy at the main bearings. In every case it amounts to one-third or one-half of all the friction resistance of the engine, the higher figures being given by the condensing, the lower by the non-condensing engines, except that the first experiment, with the straight line engine, gives as high a figure as the condensing engines—a fact due, however, rather to the exceptionally low total than to exceptionally high friction on the main shaft. The second highest item is, in all cases apparently, the friction of piston and rod, the rubbing of rings, and the friction of the rod packing.

This is a very irregular item, as would have been naturally anticipated, and amounts to from a minimum of 20 per cent. to some higher but undetermined quantity. The third item, in order of importance, is the friction of valve, in the case of the engines having unbalanced valves. This is seen to be hardly a less serious amount than the frictions of shaft and of piston. But it is further seen at once that this is an item which may be reduced to a very small amount by good design, as is evidenced by the fact that, in the straight line engine, it has been brought down from 26 to 2·5 per cent. by skillful balancing. Ninety per cent., therefore, of the friction of the unbalanced valve is avoidable or remediable. The importance of this fact is readily perceived when it is considered that not only is it a serious direction of lost work and wasted power and fuel, but that the ease of working of the valve is a matter of supreme importance to the effective operation of the governing mechanism in this class of engines. No automatic engine can govern satisfactorily when the valve is unbalanced, and is certain to throw much load on the governor. The frictions of crank pin, of crosshead, and of eccentrics are the minor items of this account; they are comparatively unimportant.

Studying these facts with a view to further improvement of the steam engine, certain inferences are at once obvious. The improvement of the steam engine has to-day reached a point beyond which, in its thermodynamic relations, but little advance can be anticipated. Under usual conditions of operation of our very best engines, they are so near the efficiency of the ideal engine, working under precisely similar conditions, that the range of possible gain left to us is too

small to permit us to look in that direction for rapid or important changes in further increase of efficiency and economy. Where the ideal engine would consume ten pounds of steam per horse power per hour, we have actually reached as little as fourteen, if the latest and best reports of the best of modern engines may be accepted as substantially correct; and even this thirty per cent. margin is reduced by practical conditions restricting expansion. If it were to be asserted that we may hope to bring the consumption of steam in good engines of the best type down to as low as twelve pounds per hour per horse power, it is probable that the most experienced and best informed engineers would think it a somewhat rash statement; but, in the opinion of the writer, that is what the tendency and rate of recent improvements would seem to promise for the immediate future, assuming that no very great increase in pressures and temperatures of steam may be expected. Practically, also, it is now known that the highest duty is not the most desirable, nor, on the whole, the most advantageous condition of operation of the engine, and we are restricted to lower duties and reduced efficiencies whenever we consider financial relations. It is, nevertheless, the fact that the conditions of improvement are those which also give higher ratios of expansion for the best point of cut-off and most advantageous ratios of expansion. The duty to seek further means of improvement and higher efficiency becomes all the more imperative when we study the practical conditions under which our engines must be employed. Having, however, as just remarked, so nearly reached the limit of possible gain on the thermodynamic side, it becomes advisable to seek the more carefully for opportunities of improvement in other directions. We have, in the work outlined in this paper, both the directions shown us and the specific method of procedure suggested.

The real, final efficiency of the steam engine, or of any heat engine, as has been somewhat fully shown in earlier papers by the writer,* and later by others, is composed of the resultant of several distinct efficiencies, as the thermodynamic efficiency, the efficiency of the engine as a heat preserver and user, the efficiency as a machine, and the efficiency as a whole considered from a commercial standpoint. Of these several efficiencies, we have in this investigation the means of studying the efficiency of the machine as a division of the whole within which to seek the best means of securing a gain of total efficiency. The real and final efficiency is certain to be increased if we can effect an improvement at this point, whatever the extraneous conditions of operation. Finding little chance of gain thermodynamically, it becomes our duty to ascertain what are the probabilities of securing progress elsewhere. It is at once seen that the difference here between the real and the ideal engine is greater than in the domain of thermodynamics, the best cases being in both instances taken. Those engines which are most nearly perfect thermodynamically are undoubtedly often least perfect, or at least of the least perfect types, when the efficiency of the engine as a machine is studied. Few of them have less than a total of twenty per cent. friction; while they are sometimes probably nearer the ultimate limit of improvement, practically, as converters of heat into work. We are now, for the first time in the history of the theory of the steam engine, in a position to say just where the losses of the machine are in detail, how we are to endavor to reduce them, in what degree we may hope for such gain, and where it is to be found, if effected at all!

The first and most remarkable fact to be noted is the extraordinary amount, absolutely and relatively, of the friction of the crank shaft. This amounts to nearly one-half of the whole waste, and to from five to ten per cent. of the whole power of the engine, in the cases here examined. It is remarkable not only for its amount, but also because of the fact that we had begun to believe that, under similar conditions of pressure, speed of rubbing, and of lubrication, it was perfectly practicable to bring down the coefficient to less than one per cent. and perhaps to as little as one-tenth of one per cent. Here, however, we find, on examination of Table X., that this coefficient rises, in the unloaded engine, to about 0·30 as a maximum, and, as a minimum, to at least 0·09; while it only falls to 0·04 in the best case, with the increase of pressure on the bearings due to full load and power. This is the more astonishing when it is considered that, on the axle of the car wheel, it has been found often that the friction is a fraction of one per cent. and often as low as one-tenth per cent. Here is evidently the first place in which to seek further improvement. If this item can be brought down as low as in car axle journals, the efficiency of the engine as a machine will be increased by about five per cent. in the very best cases, and by ten per cent. in ordinary engines. How this is to be done can be best ascertained when it is found just what are the causes of this extraordinary and previously unsuspected loss. The only conditions apparent tending to exaggerate this waste are the continuous rotation in one direction and the unintermitted pressure of the journal in its bearing. It would appear probable that it is a case of commonly imperfect lubrication. Could the oil bath system in method and in results be secured here, it would seem probable that the friction might be enormously reduced. It would even in many cases, if not in all, pay well to have a thoroughly reliable system of lubrication by means of a forcing pump that should insure the support of the journal upon a cushion of lubricant, thus making its action analogous to that of the "*palier glissant*" of Giffard and the "water bearing" of Shaw and of others.

The second and most obvious conclusion is that the valve should be balanced and so connected as to cause the least possible waste by friction through its motion or that of its moving connections. There is evidently no probable line of improvement so certain to yield a large and profitable result as this. The balancing of the valve has been accomplished, and frequently, during many years past, and so successfully that there is no excuse for neglecting this point in even the cheapest classes of engines. No engine can be considered as belonging to the best class which is not either provided with a balanced valve or which has not a system of valve gear, as with some of the "drop cut-off" engines, in which the loss in this direction is rendered insignificant. Here lies an opportunity to raise the efficiency of mechanism of ordinary engines at least five per cent., and of the best of engines with unbalanced valves two or three per cent. It is evidently better, in many cases, to have a valve which is balanced, though slightly leaky at times, than to use an unbalanced valve, though absolutely tight at all times. The simple fact here revealed, that nine-tenths of this friction may be avoided, is very important.

The third item in order of importance is the friction of piston and its rod. This is as great as that just referred to, and is vastly more variable with the class of engine, and probably in the same engine with differences in handling, and especially in setting up packing and springs, where they exist. The writer has often known the power of an engine to be sensibly affected by the carelessness or inexperience of the attendant, who had screwed up his packing in the rod stuffing box too tightly, and has, on more than one occasion, had a similar experience where the rings were set out too hard. The metallic packings and the unpacked pistons and rods now coming slowly into use will unquestionably do much to remedy this defect of the average engine. Meantime, with the older design, it is perfectly possible to keep piston and stuffing box tight without wasting much power, or by slowing down the engine by conversion of heat into work at points where the operation is likely to produce serious harm as well as waste. Rings are much oftener too tight than too loose, and a stuffing box should only be set up when the engine is running, and then only with fresh packing and not more than is sufficient to check any visible leakage. New packing in a well made box never needs much compression, and when it becomes necessary to screw it down hard, it is time to replace it by new. Any packing that compels severe compression when new should be promptly condemned.

The remaining items are of minor importance as bearing upon the efficiency of the machine, and they are all obviously easily taken care of by a good designer and a good engineer in charge. Here, if anywhere, it is the fact that freedom of lubrication is the essential consideration, and the more nearly most absolutely flooded the parts can be, and the more absolutely certain lubrication can be made, the better, and irrespective also, to a great extent, of the cost of the lubricant. Any lubricant freely used can be filtered and cleansed in such manner and so effectively that its more or less free supply to the bearing is a matter of no consequence as a matter of first cost; while the cost of wasted power and fuel, and of repairs due to excessive friction and wear, will usually enormously exceed any apparent gain in that direction. This latter consideration has been very fully treated by the author elsewhere,* and is probably also too familiar to engineers of experience to make it advisable to extend the limits of this paper so as to include more of detail in this and other matters. The importance of the work of which this is the history is sufficient, however, probably, to justify the length to which the paper has already extended.

By reducing the several items of waste and loss above enumerated to their minimum amounts, in the various ways pointed out, and by other less obvious expedients, it is evident that the efficiency of the machine may be so far advanced, in the case of the ordinary engine, as to give us the power of applying from five to ten per cent. of the total indicated power of the engine to useful instead of to wasteful purposes, and thus to effect a gain of no small amount by improving both sides of the account.

Messrs. Carpenter and Preston have done other work of value to which it may be possible to give attention later, and Professor Carpenter is independently pursuing the study of the internal friction of engines. It is hoped that we may, in time, secure a very large body of valuable data, and especially that we may, after a time, be able to indicate the laws of its distribution with some accuracy for all types and styles of engine in common use.

* On the Several Efficiencies of the Steam Engine. Trans. Am. Soc. M. E., Vol. viii., p. 86.

* Friction and Lost Work in Machinery and Mill Work. J. Wiley & Sons, New York, 1885.

THE FORTH BRIDGE.

THE vast undertaking now under construction across the Frith of Forth at Queensferry is being rapidly pushed forward, and the contractors, Messrs. Tancred, Arrol & Co., are taking all possible advantage of the calm weather and fine autumnal days, as abundantly evidenced by the erection during the past month of over 2,000 tons.

Our illustration is a general view of the structure from the southwest, taken from a point on the present North British Railway, about midway between Newhall's platform and the South Queensferry station. Considerable progress has been made since this view was taken, August 1. At the present time the wind fence of the south approach viaduct is nearly completed, imparting a finished look to this portion of the structure. The south cantilever pier now stands at 90 ft. above ordnance datum, or 28 ft. below the top, while the corresponding pier on the north or Fife shore is completed as high as the bottom of the top cornice. The Queensferry main pier has been erected in both north and south cantilevers as far as the center of bay 3, similar progress having been made with the Fife main pier. At Inchgarvie progress is not quite so marked. On the south side, however, commencements have been made with the erection of ties 3 and struts 3; while on the northern cantilever strut 2 is built up about one third of the distance from the junction with strut 2 to the upper member, and tie 2 is built down to its connection with the lower member.

We are indebted to the courtesy of Sir John Fowler, K.C.M.G., and Mr. Baker, the engineers of the bridge, for the photographs we are enabled to place before our readers.

The Forth Bridge possesses a great popular interest entirely apart from that felt by engineers. The *Saturday Review* of the 6th October expresses this so well that we make no apology to our engineering readers for reproducing portions of our contemporary's comments:

"There is a side in the great development of mechanical science which is not purely mechanical. Emotions of an æsthetic nature are undoubtedly stirred in most human breasts by the exhibition of vast forces utilized and controlled with almost microscopic exactness.

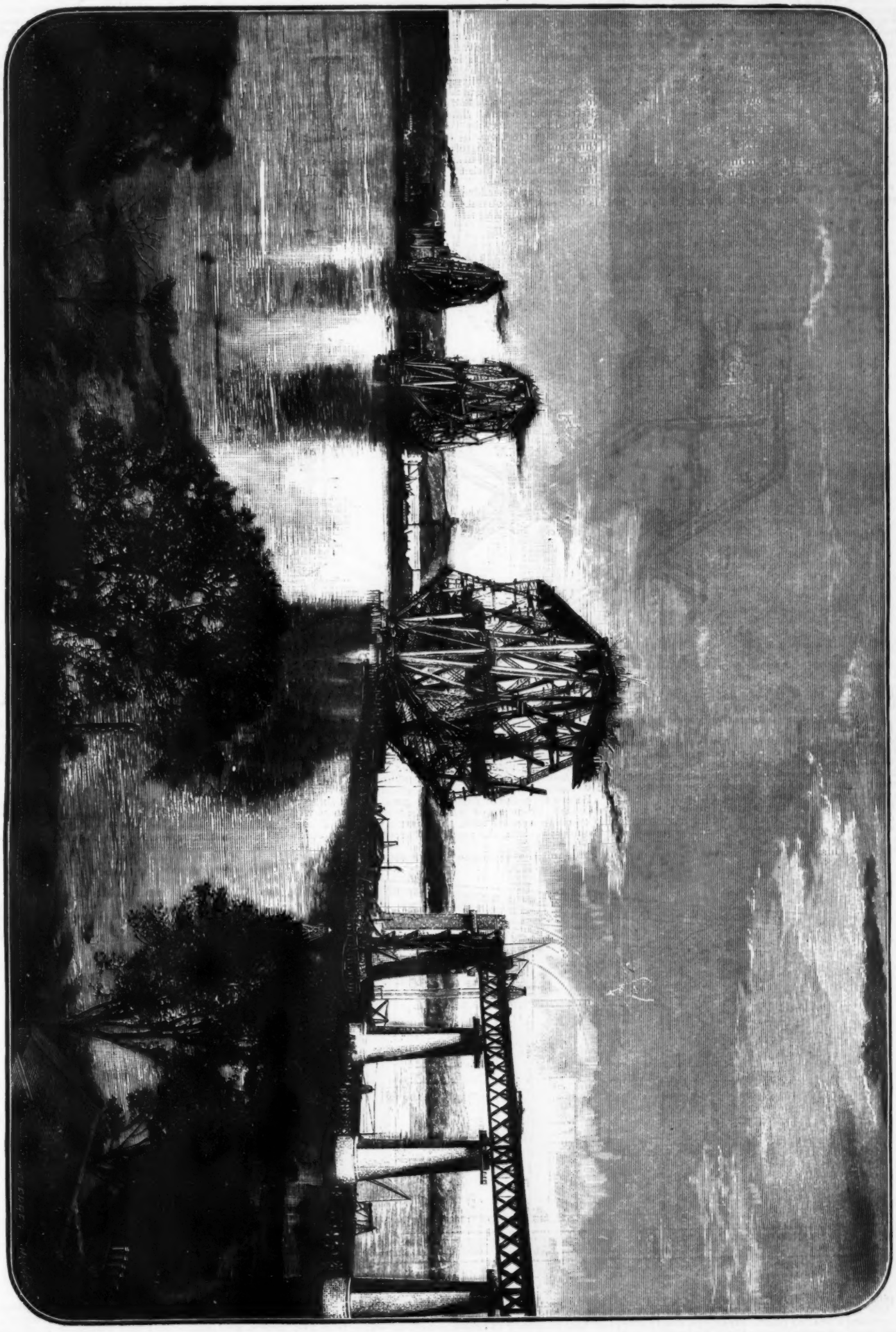
"It is probably this feeling which makes the bridge now being constructed over the Forth at Queensferry so popular among sightseers, most of whom are totally incapable of grasping the principles of its construction. No one could ever describe it as being beautiful in the ordinary sense of the word, either in its present incomplete form or as it will be when ready for traffic. And those who live in its neighborhood may have a just cause of complaint that it has spoilt much of the picturesque appearance of the scenery which surrounds it. But scenery as picturesque can be found eleswhere, whereas the structure is at present unique, and is as impressive as it is solitary. The whole length of it is rather over 2,600 yards, and the highest points of the three piers are 350 ft. above high water mark. The main part of it will consist of two enormous spans, measuring 1,710 ft.—a third of a mile—each. The bases which support the framework resting, one near the north side, one near the south side, and one close to the island of Inchgarvie, each consisting of four great cylindrical granite pillars, rising just out of the water. The best way to picture it to one's mind is to imagine four great pairs of lazy tongs, which diminish in size toward the further ends, and which are stretched out from these piers across the sea to a distance of 680 ft., a good deal more than half way across the Thames at Westminster. The big end of the lazy tongs—or the distance between where the thumb and the finger would be—is 350 ft in height, and the little end is 150 ft. above the sea. One of these great lazy tongs starts from each of the granite pillars, and they are tied together in couples back to back, so as to look like pairs of enormous brackets, balancing each other at their big ends, and stretching out their small ends unsupported over the water. But these great cantilevers, even when finished, will not meet, and there will still remain a length of 300 ft. between them. This will be bridged over by a latticed girder, whose ends rest on the extreme points of the lazy tongs.

"When finished, these spaces will look as if they had been to some extent constructed on the principle of the arch, which will give them to the ordinary eye an appearance of security, which indeed they no doubt possess, but from a different cause. But as they stand now the effect is almost magical. They are actually being built out in space. Bit after bit is being added to them with no support from scaffolding, and with nothing but the ebb and flow of the tide at a dizzy distance below. As the work proceeds, cranes are moved onward, and, with their arms hanging over the edge, haul up plate after plate to be screwed on to what has already been fixed. On the end of these arms men sit directing the movements of the various portions of the cranes as may be required. An ordinary arch, of whatever material it is built, has to be made on a framework or centering to support it until complete, when the wedge shape of its component parts prevents it falling in. But here a thing which looks in shape from below like an enormous arch of iron framing, large enough to very much more than cover the longest bridge in London, and strong enough to carry two trains, is being pushed out day by day from each end, as a barber sticks out his pole at his shop door. The best way to realize this extraordinary peculiarity is to walk along the top of this enormous bracket, stretching out hundreds of feet. It is then impossible not to think that as one advances the mere weight of the human body will not overbalance the whole structure and upset it into the sea. In reality the weight is less in proportion than that of a fly walking along a gas bracket.

"In the case of all large structures, architectural or engineering, when the object of the spectator is to obtain some idea of their immensity, he should attempt to take measure by some familiar objects, themselves large enough to be easily comparable with the whole. It is no mere useless bit of information that the ball at the top of the dome of St. Paul's Cathedral will hold twelve people, or that the pen of St. Luke in the dome of St. Peter's at Rome is 6 ft. in length. The human eye requires every assistance it can get in conveying a sense of bigness; and the skill of the architects of great buildings may be to some extent judged by whether they have succeeded or not in giving the spectator an impression of size at his first glance. In the case, for instance, of St. Peter's, it is a common remark of the ordinary visitor that it is so well proportioned that it does not look its size.

"This is a curious view. Why should any one go to the expense of a big building in order that it may look as if it was a little one, unless there is some utilitarian object to be gained? The particular reason why St. Peter's almost invariably conveys this impression of disappointing insignificance at first sight is the fact that it is designed with its parts few and large, instead of more numerous and smaller. It is as if it had been intended to be half its size, and had then been increased by calling 6 in. a foot on the scale of the plans. In a much greater degree, the same is true of a building like the Forth Bridge. From many points of view it is an intellectual effort to realize its dimensions. One has to go round about its piers in a boat, and look at the great steel tubes, to force one's self to realize that they are 12 ft. in diameter, although from a distance they seem to be but the size of a ship's mast. One has to think of these structures, which look like mere scaffolding, as being made up of members each as large in section as the floor of a room.

"If, however, a general view of the bridge requires calculation and familiarity for the full appreciation of its scale, this is certainly not the case when the spectator moves about among the struts and ties, piers and braces. The sense of bigness is then forced upon the mind at every point. Standing on the platform at the base of the piers, and looking upward, one sees the pillars of steel stretching away, apparently, indefinitely, and the great curved under side of the cantilevers reach out till it seems as if no force that human skill could devise could hold them up. But the most impressive thing of all, perhaps, is being raised in an iron cage by a wire rope which looks like a mere thread in comparison with the surrounding masses of iron. Looking up, the holes in the various platforms through which the lift has to pass seem like the joints of a telescope seen from the wrong end, and one wonders how the big cage, which holds ten people, is to pass through the square aperture, which seems to be the size of a pin hole, above. But as the lift ascends the holes seem to grow, and one steps out on to the top platform over a space through which a glimpse can be caught of the engine which has hauled up the lift, looking like a toy thing, 350 ft. below. Nor is the sensation experienced when standing on the top platform in any way disappointing. One gets all



THE [illegible]CH BRIDGE, FROM THE SOUTH-WEST.

the correct feelings of things below looking as small as they ought. Even H.M.S. Devastation seems as if it might be purchased, with great advantage, as a present to a nephew with a promising mechanical turn. But the peculiarity of standing on this height, as compared with church towers and other elevated places of interest frequented by tourists, is the fact that one is standing on a few temporary boards laid across an open framework. There is a sense of the stresses and strains, of the tensions and compressions, which all these great iron muscles are subject to. And he would be an idiot who did not feel that great engineering works such as this have a poetry all their own."—*The Engineer.*

THE PLANT OF THE BOSTON HEATING COMPANY.*

By A. V. ABBOT, Chief Engineer of the National Superheated Water Company, of New York.

A FEW days ago one of the local papers facetiously remarked that "the citizens had, during the past few months, a good chance to examine all the subsoil of the Boston streets, for within that time nearly every cubic inch of it had been frequently exposed to view." Now I am glad to have an opportunity of explaining to the scientific portion of Boston why some of this exposition of the subsoil has taken place, not with the view of mitigating any of the trouble or inconvenience that has been experienced, but to enable you to draw on your imaginations and to consider some of the advantages that will be derived in the future.

If Herbert Spencer had written upon the evolution of a city, I think that he would have remarked that the line of progress was from the individual to the corporation. In the small village each man has his cow, his well, his kerosene lamp, and his wood pile; in the city we have milkmen, a gas company, the municipal water works, and we hope to have very soon a heating plant. Strangely, nearly every domestic want, excepting that of heat, has been already supplied in the larger cities from corporate institutions.

In a few places attempts have been made to introduce some means of delivering heat from a central station. Probably Pittsburg, from the advantages derived from the almost inexhaustible supply of natural gas that there exists, has made a more widespread success in this direction than any other place. From the gas wells in the vicinity of that city an enormous supply of natural gas can readily be obtained at a pressure sufficient to force it many miles from its source, and to distribute it to all consumers. Obviously, very few places have such natural advantages, and some other means must be devised if it is desired to furnish heat in a location not supplied with gas wells. Several plants have been introduced to deliver heat by means of a number of boilers located at a central station supplying live steam to a series of pipes extending through the streets of the district to be served. The steam thus distributed may be used in any way in the same manner as if it was drawn directly from the boiler itself. Where plants of this kind have been carefully introduced with appropriate engineering skill, and with due precautions against the liabilities to which they are exposed, steam heating has been successful.

Recently another idea has been introduced which, it is believed, will obviate some of the difficulties which attend the use of steam for the distribution of heat on a large scale, and which will enable the necessary plant to be constructed much more cheaply. This system involves the circulation from the boilers of hot water, not of steam.

The object of the heating system is to distribute heat from place to place, and whatever means is used to carry heat from point to point is simply auxiliary, the distribution being the end to be accomplished.

Before we proceed further, we must establish some standard by means of which heat can be measured. If one is to measure milk, the quart is the unit; if land, the acre; if cloth, the yard; and so with heat, a unit is necessary.

The unit that is adopted in this country is the quantity necessary to raise a pound of water one degree; strictly I should say that a unit of heat is the quantity of heat necessary to raise a pound of water from 38½ degrees to 39½ degrees, the point of maximum density.

Water was selected as a measure for heat, because it was supposed to have the greatest capacity for heat of any known substance. Now a solution of sugar and element of bromine are found to have slightly greater specific heats. With the unit of heat we can express quantities in terms of that measure—for example, one thousand units of heat is the quantity necessary either to raise a pound of water one thousand degrees or one thousand pounds of water one degree. It is true that the specific heat of water increases slightly as the temperature rises, but that increase is so very small that for anything but the most accurate and exact calculations it may be neglected.

To carry any substance from one point to another, we wish to select for our means of transportation that arrangement which will enable us to convey the greatest amount for the least expenditure. If we want to haul a thousand tons of earth, we get the largest cart that the horse can easily draw; if we wish to carry a load of rails, we obtain the largest car that can accommodate them. So, for the transportation of heat, we naturally select that substance which will convey the largest amount of heat. Mercury, oil, steam, hydrogen gas, or petroleum could be employed; but inasmuch as water, per unit of volume, will contain the most heat, it is obvious that it is best adapted as a vehicle. It would be possible for us to use a solution of bromine or sugar, to which I have alluded, but these substances have too slight an advantage in specific heat over that of water to render their use advisable.

Reference to the accompanying illustration, Fig. 1, may aid an understanding of our system. At a central station* a number of boilers are located, exemplified in the illustration at A. From the boiler, A, proceeds a pipe, C', to a pump, B. This pipe is attached to the suction end of the pump, and consequently the action of the pump withdraws the water from the boiler. Proceeding from the discharge end of the pump a pipe, C, extends through the streets, and returning to the central station, enters the boiler at C''. As soon as the pump is set in operation, the water flows out of the boiler by the suction pipe, C, and is forced around through the streets and back again into the boiler by the pump. If, during its passage, no water is taken from the main, every stroke of the pump withdraws from the boiler and returns to it again an equal quantity of water. In reality the office of the pump, B, is simply to sustain a continuous circulation through the hot water main.

Directly beneath the hot water main, C, there will be seen the pipe, D, which in the station terminates in the tank, D'. This second main collects the water as fast as it is used and cooled, and returns it to the station, from which function it derives the name of the return main. As the return main empties into the tank, D', all the water which is cooled and carried back to the station is delivered into this tank, from which a second pump, D'', draws the water and forces it back into the

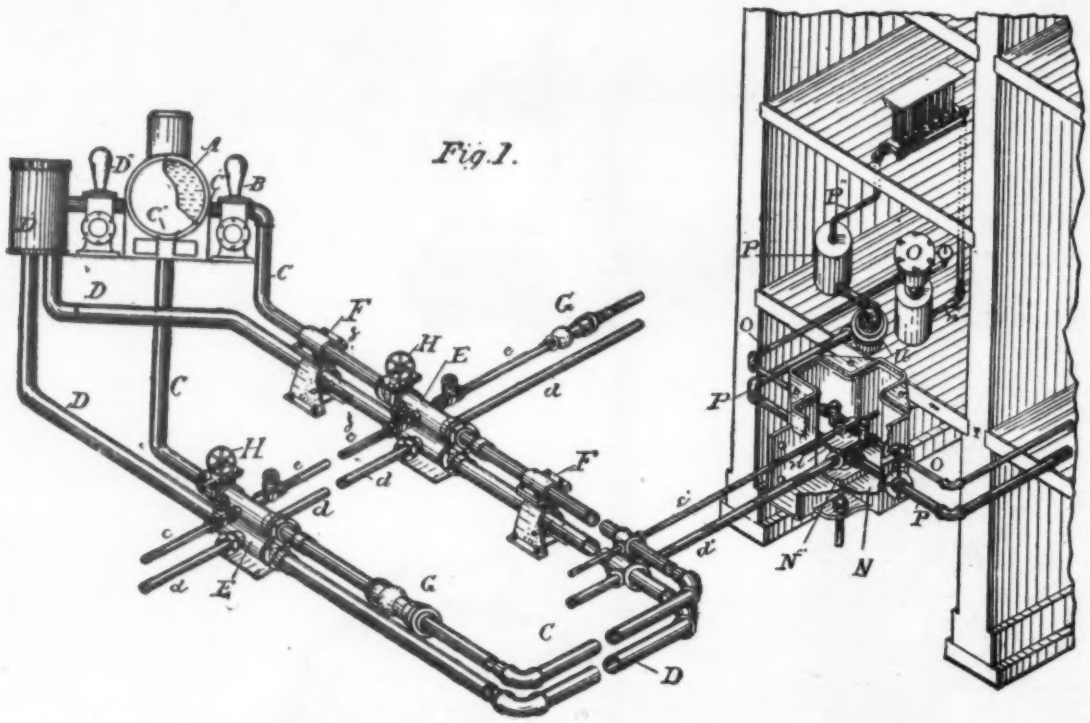


Fig. 1.

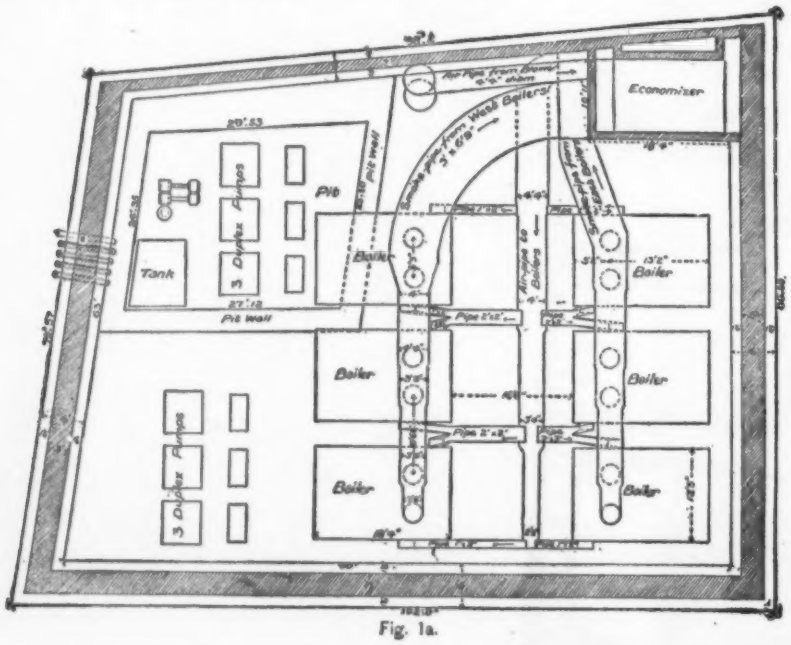


Fig. 1a.

FIG. 2.—BRACKET.

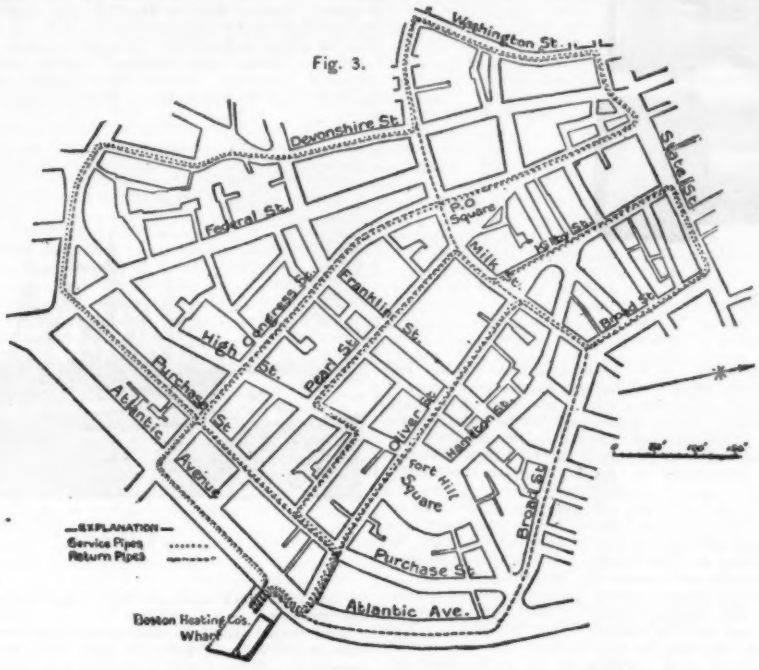
* Read before the Boston Society of Civil Engineers, November 16, 1887. From the *Journal* of the Association of Engineering Societies.

* The plan of station is shown in Fig. 1a.

boiler, again to receive a fresh quantity of heat, and to be ready for another journey through the supply main.

From point to point along the supply main small pipes, *c'*, extend to the curbstone and terminate in the service box, N. The pipe in the service box is so arranged as to enable a single box to supply three houses. This is accomplished by capping the end of the pipe with a three-way tee to which are attached three asbestos cocks. From this tee in the service box small copper pipes, O, extend into the adjacent houses, furnishing them with a supply of hot water. Directly beneath the supply pipe, *c'*, is a similar though larger pipe, *d'*, to collect the cooled water from the houses and conduct it to the return main. This pipe, *d'*, also enters the service box; and there, by a similar arrangement of tees and cocks, is enabled to receive the water from the three buildings which the hot water pipe directly above supplies.

Fig. 3.



At the risk of being a little tautological, I will very briefly go over the circulation again, so as to emphasize the way in which the water passes out of the station, through the streets, and back into it again.

We have a boiler in the station; there may be a single boiler or there may be a large number, depending on the size of the district to be heated. From the boiler the water passes into the suction end of the pump; from the discharge end it runs through the street and back into the boiler again, maintaining a steady circulation for the purpose of keeping a constant temperature in the supply main. From various points on the supply main small pipes are laid, extending into the houses and stores, from which a quantity of water may be drawn off and used in any way. After the water is cooled it returns through a second pipe into a second main laid under the first, which returns the cooled water into a tank, from which tank a second pump forces the water back into the boiler again.

In the plant which we have introduced this season the return mains are all laid to grade, so as to conduct all the cooled water to the station by gravity. It is, however, possible to arrange the house appliances, which I shall describe in a few moments, so that they may be capable of returning the water to the station over a higher grade than that at which they are located.

Neglecting any slight leaks, unavoidable in so large a plant, and excluding waste that may occur from a thousand and one contingencies, the system, once filled, will always remain full, the water being simply the vehicle by means of which the heat received from the central station is transported to a distance. It is the car in which freight is carried, the water itself having nothing to do but act as a messenger, and after it has left its load of goods it returns to the station to receive another and repeat its journey.

Those who have watched the work in the streets during the past three months have noticed that we have excavated a trench some 2½ or 3 ft. wide, and varying in depth from 2½ to 7 or 8 ft., having an average depth of 4 ft. The trench has been excavated to grade between the street corners. Along the bottom of the trench we have spread a uniform layer of concrete 8 in. in thickness, made of one part of cement, two parts sand, and two parts broken stone, thoroughly rammed into place. Once in about 15 ft. a brick pier has been introduced in the concrete and solidly embedded therein. On this brick pier has been placed an iron construction called a bracket, Fig. 2.

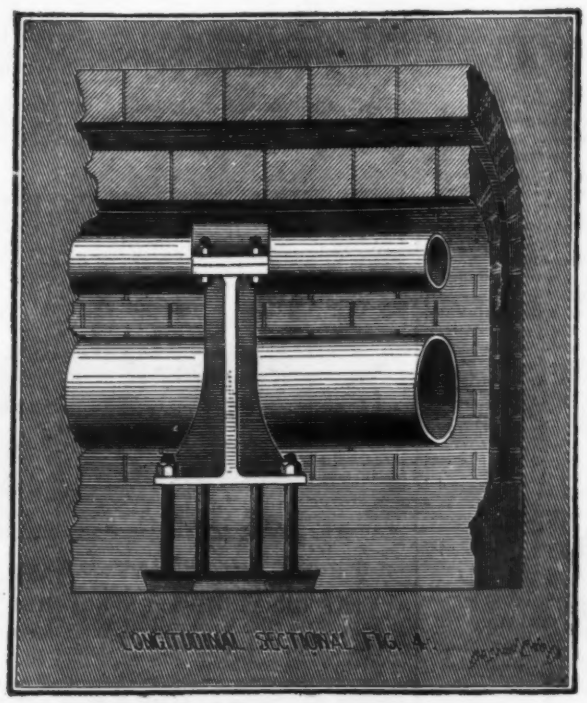
The bracket consists of a solid, arch-shaped casting supporting a roller covered by a cap. The office of this roller is to carry the four-inch supply pipe and allow it sufficient ease of motion so that it may readily expand and contract under the variations in temperature; while the cap surmounting the whole confines the pipe sufficiently in its place so as to maintain it in a fairly straight line and prevent it from becoming in any way displaced. The whole bracket stands on top of the brick pier, while directly underneath the arch of the bracket a second roller, placed on a small iron stand, is seen, the office of which is to support, in a similar manner, the eight-inch return pipe, and to permit of perfect freedom for expansion. It would seem that there was quite a disproportion between the supply and return pipes. The supply pumps at the station, taking their suction from the boiler, are able to maintain through the small supply pipe a rapid current. We expect to carry a circulation, depending on the demand on the system, of from five to ten feet a second. By means of the pumps, this forced circulation is easily accomplished. While a small pipe for the supply pipe adds to the frictional resistance offered to the pumps, the radiating surface is largely diminished, the cost of the pipe is much decreased, and the ease of construction is greatly facilitated. In the return pipe, when the water is to come back to the station by gravitation alone, it is necessary to decrease the frictional resistance as much as possible to afford an abundant chance for the water to run back easily and freely, no matter whether the discharge from the houses is regular or irregular. So we have for the return pipe an eight inch pipe, and for the supply a four-inch.

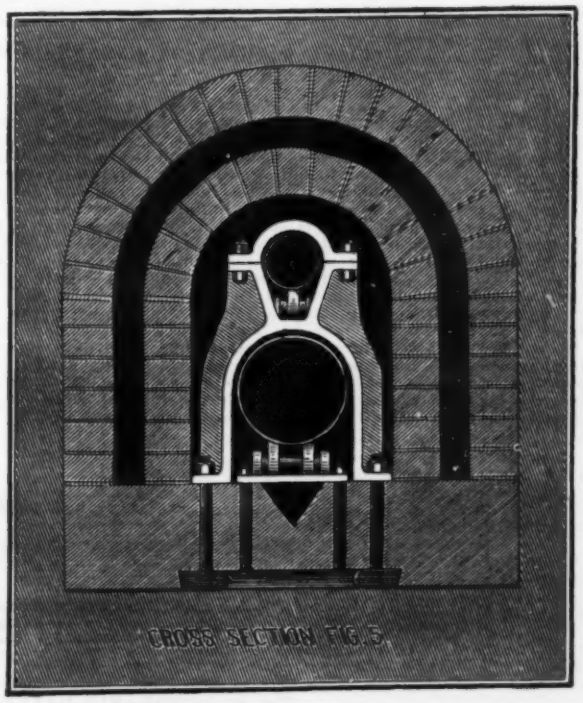
The territory covered by our plant is shown on the map, Fig. 3, while the construction of the conduit is illustrated by the longitudinal section, Fig. 4, and transverse section, Fig 5. In actual steam practice it is found absolutely essential, wherever there occurs any change in direction of the pipe line, to introduce some means to provide for the expansion which is due to the variation between the temperature at which the pipe is laid and that which it attains so soon as circulation takes place. Experiments on various mechanical contrivances have convinced us that the best joint to be used for our purpose is the telescope expansion joint.

The expansion joint (Fig. 6 elevation and Fig. 7 section) consists of a large casting having two longitudinal holes, into which the ends of the supply pipe and return pipe are introduced. At one end of the casting these holes are supplied with threads, E', Fig. 7, and the ends of the pipe are screwed into them in the same way they are introduced into an ordinary coupling. By this means, as the expansion joint is firmly bolted to the masonry foundation, the joint forms an anchorage, so that one end of the section of pipe to which the joint is attached is firmly fixed and held in its place. At the opposite end of the joint from the screw threads the casting is enlarged so as to receive two sleeves of phosphor-bronze, K, containing a large percentage of aluminum. These sleeves form the movable part of the joint, and, after being introduced into the casting, are carefully packed with a rope made of pure asbestos fiber, J, impregnated with black lead. This packing is introduced between the casting and the phosphor-bronze sleeve in the same manner as ordinary packing is introduced into stuffing boxes; and the gland, L, is firmly fastened on top of the packing. The outside end of the phosphor-bronze sleeve is furnished with a screw thread, C, to which the end of the pipe is attached, so that when the pipe expands or contracts, the phosphor-bronze sleeve moves in and out of the casting and accommodates itself to the varying lengths of the pipe. By means of the gland in the stuffing box and a corresponding ring, *e*, on the inside of the casting, the phosphor-bronze sleeve is very carefully aligned, so that its motion in and out is in a straight line. In the joints which we have introduced here, the sleeve of the supply main is long enough to give a motion of 12 inches, while that of the return main is about 8 inches. Inasmuch as these joints are placed, on an average, as often as once in 100 or 150 ft., and the maximum motion for which they will have to provide being only from 4 to 6 inches, it will be seen that there is an abundant margin to prevent any possible cramping.

Last spring we built an experimental joint of this kind, and setting it up in our shop in New York, put on a steam pressure of four hundred and fifty pounds to the square inch, and attaching a lever to the sleeve, worked the joint to and fro several thousand times, corresponding to several thousand expansions and contractions of the pipe. At the end the joint was as tight as it was in the beginning, not leaking a drop.

Each one of the expansion joints is placed in a manhole, so that it is perfectly accessible to inspection or repairs. On the fixed end of the expansion joint there is a valve. The object of this valve is twofold. Beyond the valve, in the casting of the expansion joint, is a side outlet, also provided with a valve. In the growth of the system it will soon be necessary to introduce cross pipes extending between the main supply pipes passing through the side streets, so as to give a hot water supply to the intervening buildings. For example, there is a manhole at the corner of Devonshire and Franklin Streets, and one at the corner of Franklin and Congress. At each of these manholes occurs an expansion joint. At any time it is simply necessary to connect this valve at Congress Street with





the corresponding one at Devonshire Street, and then, opening the valves, a stream of hot water would flow between the two streets, making a cross connection from which the buildings on those streets could be supplied.

When it becomes necessary to repack the expansion joints—though, to the best of our belief, the packing will last a long time—it is only necessary to shut off the valve at one manhole and a corresponding valve at the next to cut a section of the main out of the circuit; and by opening a side valve, we can discharge the water contained in the main into the conduit, which is provided with a drain for this purpose, and then, by blowing a stream of air into the manhole, cool it off sufficiently so that the workman can open the gland and introduce a new packing—all in the course of a few hours. It could easily be done at night time, when the demand for heat was a minimum.

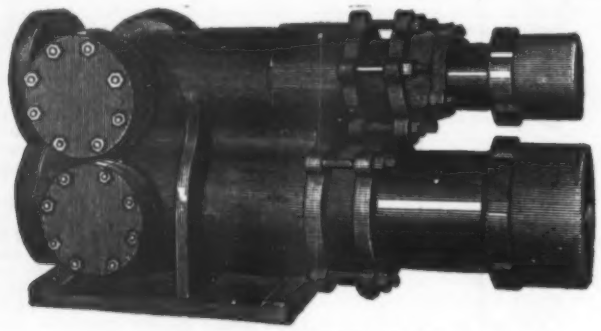


FIG. 6.—EXPANSION JOINTS.

Many questions have been asked as to the safety of this system—pertinent questions, too, because exaggerated statements have been current as to the pressure which we propose to carry.

The supply pipe is made of what is called "extra heavy" pipe, the bursting strain of which is twelve thousand pounds to the square inch, as we have ascertained by testing a number of samples to destruction. Every piece of pipe that has gone into the streets has been tested to four thousand pounds to the square inch as a proof test. After the main is laid in place every section—that is, the distance from one expansion joint to the next one—every section, including all screw threads, all of the packing of the expansion joints, and all joints, have been tested to fifteen hundred pounds; and now that the main is completed, we are at the present time making a test of the whole main up to fifteen hundred pounds, from the station round back to the station again. So when the main is completed and ready for use, it will have received, first, a test at the mill of four thousand pounds; second, a test, by sections, of fifteen hundred pounds; and third, a test of the main as a whole of fifteen hundred pounds, all being pressures per square inch.

We expect to deliver water to our consumers at a temperature of about four hundred degrees, which corresponds to two hundred and fifty pounds to the square inch absolute, two hundred and thirty-five above the atmosphere. Probably the water will have to leave the station slightly higher than that to provide for the unavoidable radiation. If we send the water from the station at three hundred pounds to the square inch, and allow one hundred pounds for pumping friction, the total pressure on the main would not exceed four hundred pounds; and as the main has been tested to four thousand pounds, there is a large margin of safety.

As an additional precaution, we have, once in every section, a check valve so arranged as to shut off automatically each section of the main in case of any accident. Malicious injuries might occur, for it is conceivable that in times of strikes men might dig up the main or drive a pick into it. In the illustration, Fig. 8, a cross section of this valve is shown in connection with the expansion joint. It will be seen that on the left hand side of the joint the casting is enlarged so as to form a spherical cavity into which one end of the pipe line, C, is screwed in the same manner as into a regular coupling. The spherical cavity contains a ball supported on two ribs so planned as to allow the ball when at rest to remain at the bottom of the cavity. The end of the pipe, C, is chamfered so as to form a valve seat. Under ordinary circumstances, the ball remains at rest on the ribs. Should, however, any rupture occur, the current of water flowing through the main will, by reason of the break, be greatly accelerated, and, acting on the ball, cause it to roll up along the ribs and seat itself on either side of the spherical cavity toward which the current may be flowing, thus completely shutting off the remainder of the main. The forces keeping the ball in equilibrium are its weight, acting downward and keeping it in place, and the friction of the water current, tending to force it up to the inclined ribs and seat itself against either side of the spherical cavity; so, by varying the weight of the ball, the valve can be adjusted so as to close with almost any desired velocity of current. Under maximum demands, we can use a current of 10 or 15 ft. a second, and the ball is so weighted as to close at a velocity of 20 ft. a second. Should a rupture in the pipe occur, giving a velocity of 20 ft. a second, the ball will leave its place, and, rushing up, close the end of the pipe and shut off the rest of the main. This is not simply theory, but is practice to the extent that we have made a number of these valves, and, after experiment, have found them to work very accurately.

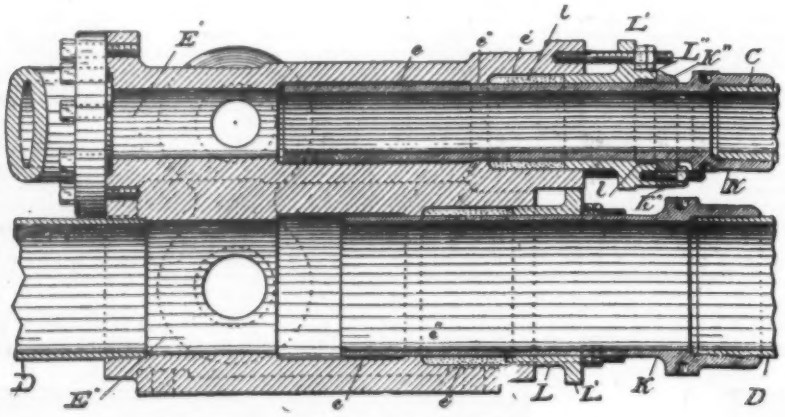


FIG. 7.—SECTION OF EXPANSION JOINTS.

Should any accident occur, either malicious or otherwise, to rupture the main, it is obvious that only the quantity of water contained between two check valves would escape from such a break. As these valves are placed at intervals of about 100 ft., the amount escaping would not exceed 20 cub. ft. The volume of the conduit is so large that, should this entire quantity of water be discharged into it, the steam formed therefrom would be quickly dissipated through the length of the conduit without producing sufficient pressure to do any damage.

(*To be continued.*)

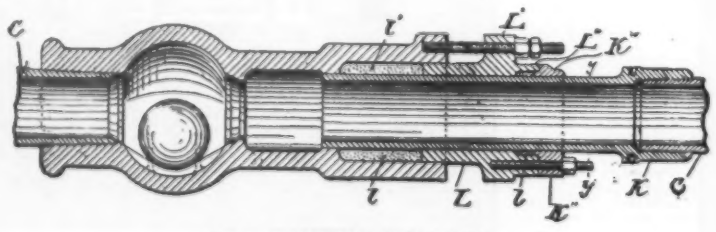


FIG. 8.—AUTOMATIC VALVE.

THE GREAT EASTERN.

ON the afternoon of the 23d of last August the Great Eastern entered the Mersey for the last time. The enthusiasm which this ship has always aroused among the English, and the interest as well, was so much the greater in that every one knew that she was to end her existence upon the shore of New Ferry.

Thanks to a skillful maneuver, performed naturally at low tide, and with the aid of two tow boats, she was, as soon as she arrived there, beached without incident. Her bow, turned toward the southwest, hid a part of the piers of New Ferry and Birkenhead.

Before proceeding to break up the colossus, which is not to be done till the end of this month, the purchasers, Messrs. Henry Bath & Co., will wait to take advantage of the equinoctial tides, so as to get her as far on shore as possible. To obtain such a result, the ship, to which are attached strong cables winding around capstans, is, by this simple means, being moved 25 or 30 feet a day. The operation has succeeded so well that now, at low tide, a person can walk around her.

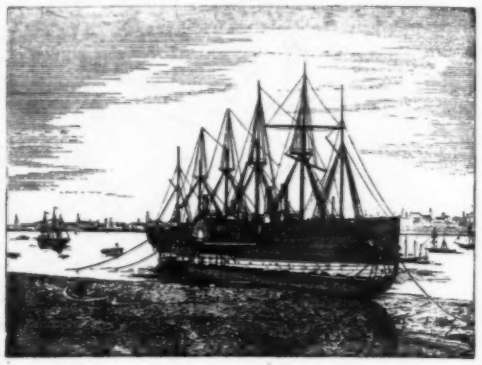


FIG. 1.

The Great Eastern was purchased for the modest sum of £20,000, say $100,100, and the owners calculate to realize a large profit upon her remains. It will take no less than two years to break her up, and the removal of the pieces and iron plates will be done with the greatest care.

Although the history of this vessel is generally known, we shall give a brief *resume* of it.

The Great Eastern was built, after plans of Brunel & Son, at Blackwall, near London, for a company which proposed to run her between England and the far East, and hoped to carry entire colonies of emigrants who were going to seek fortune in Australia. But, as great as was the conception of this floating city, the expenses calculated upon were quickly exceeded, and a failure was the result of this first enterprise, which swallowed up $8,000,000. The dimensions of the vessel are as follows:

Length at the float water line	679·6 feet.
Total breadth	82·8 "
Depth	31·6 "

She was propelled both by side wheels and a screw. Her screw engine had six boilers and seventy-two furnaces, three funnels, and a power of 1,600 horses. Her side wheel engines had four boilers, forty furnaces, two funnels, and a power of 1,000 horses. She gauged no less than 25,500 tons, she consumed about 300 tons of coal a day, and it took no less than 200 men to attend to the engines alone. No graving dock was large enough to allow her to enter to have her hull cleaned or her screw changed.

From the beginning, it had to be granted that it was necessary to put her to some other use, for, despite the abundance of canvas with which she was provided, she would have become an inert mass at the first accident that happened to her engines. An endeavor was made to utilize her for the carriage of troops to Canada, but the project had to be abandoned.

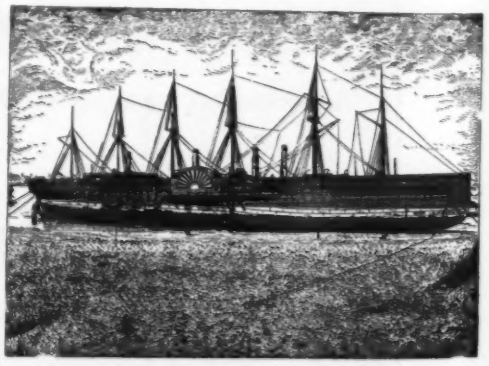


FIG. 2.

THE GREAT EASTERN BEACHED AT NEW FERRY.

It was about this time that an attempt was making to lay the first Atlantic cable, and the Great Eastern was put in requisition. Owing to her huge dimensions, she appeared to be thoroughly destined for this great enterprise, and the work was performed with success, as we know. This, therefore, is the only real service that she has ever rendered. It is now a question of ut a few years when every vestige of the colossus will ave disappeared.—*Le Genie Civil.*

HOW TO MAKE PHOTO. PRINTING PLATES

THE name collotype is now almost universally used in this country, and lichtdruck in Germany, to designate the process of printing in greasy ink from a surface of gelatine.

If a film of bichromated gelatine be dried at a pretty high temperature, be exposed under a negative, be then washed in water and dried, it will, when treated in the same way as a lithographic stone, display similar properties—will, that is to say, absorb water and refuse a greasy ink in certain places, while in others it refuses water, but subsequently takes ink.

The portions which take water and not ink are those which have not been affected by light, while those which take ink readily are those which have been greatly affected by light. Between these two extremes is a complete gradation represented in reality by a reticulation or grain, but giving the impression, so fine is this reticulation, of a true half tone.

The close analogy between this process and that of lithography will be readily seen, and, in fact, it was in attempts to impress on lithographic stone images which could be inked up like ordinary lithographic images that collotype came first to be invented. Naturally one of the substances first applied to the surface of a stone in the attempt to transfer an image to it was bichromated gelatine, and it was not for some considerable time that it was discovered that the *stone*, in fact, had nothing to do with the effect obtained further than inasmuch as it acted as a support for the gelatine film, and that other supports would do as well or better.

The difficulty found in all the first attempts at collotype, or, as it was then generally called, photo-lithography, arose from the reason that, after a few impressions had been taken, the film tore away from the support, whether it were stone, a metal plate, or glass.

The first real advance was made by Tessie de Motey, who used a copper plate, the trichromate of potassium in place of the bichromate, and a reducing agent. The copper in these circumstances had the effect of rendering the portion of the film in direct contact with it quite insoluble, and therefore making the adhesion very complete.

This process I thought had become an affair of history only, having long passed out of use, and was surprised, on recently visiting the works of Mr. Ernest Edwards, of Brooklyn, New York, to see it in practical use. I am sorry that I cannot give precise formulæ or instructions for working it, as it seems to be in Mr. Edwards' hands a thoroughly practical, working process; the copper plates having the advantage over the glass plates now generally used of non-liability to breakage.

In general use the process of Tessie de Motey was soon superseded by that of Albert, in which a plate of glass was coated with a film of bichromated gelatine. When the film was dry, the plate was laid face downward on a black surface, such as a piece of velvet, and was exposed to light. The light acting through the glass formed an insoluble substratum which adhered very firmly to it, and securely fixed to the plate a second coating of bichromated gelatine, to be afterward exposed under a negative.

This process is, I believe, still worked by some collotype printers; but I believe that far the majority now use the process which is due to Husnik. In this process a plate of glass, ground on one surface, is used as the support, and a mixture of water glass and albumen is used on this ground surface as a substratum for the final film.

The principle adopted by Albert of exposure from the back of the glass is still made use of to a slight extent at the present day with Husnik's process, as is also the discovery made long ago by Edwards that the whole film might be acted on by alum to a certain extent, being thus toughened, and might yet be quite serviceable as a printing surface for greasy inks.

PREPARATION OF COLLOTYPE PLATES.

The chief requirement for the preparation of collotype plates is a suitable arrangement for drying the films. These have to be dried at a temperature of 120° to 140° Fah. in some place where there is a free admission of air. Some dry over an arrangement of two cast iron plates between which water is kept boiling, a shallow boiler, in fact, the upper surface of which is fitted with three projections forming a tripod to hold each plate in a level position.

If this arrangement be used, it is necessary to take precautions against dust by covering the plates with a framework having muslin stretched over it, or by some such plan.

The water heater used in the open is much inferior to a drying box much in the form of an oven, commonly used. In this latter arrangement the tempera ture may be adjusted to a nicety, while it is easy to guard against dust by stretching muslin over the air entrance passage.

Some appliance is necessary for filtering the sensitive compound; it is necessary to keep up the temperature to a certain degree during the whole of this process. A useful appliance is made for the purpose of filtering solutions which require to be kept hot. It consists of a funnel stand, with a hot water jacket for the funnel. Such an arrangement may be used by the collotype printer; but if he have a drying box, he can readily enough filter a gelatine solution by placing the funnel and receiving vessel in the box, or, indeed, he can keep the solution liquid by working in front of an ordinary open fire.

The glass should be thick plate. For small sizes it need not be thicker than a quarter of an inch, but for large sizes it should be about three-eighths of an inch thick. The great essential is that it be perfectly flat.

The production of a ground surface is so very simple that the photographer will probably prefer to produce it himself when he requires it, rather than to purchase it ready ground for him.

Two plates of glass are taken, a little flour emery and water are laid on the face of one, and the other is worked with a circular motion over it. The result in a very few minutes is a depolished surface.

The chemical substances used for the films of the plates are all well known to the photographer, and the only one that calls for any particular mention is the gelatine. It will readily be believed that on the quality of this depends in a great measure the success or the reverse of the process. The qualities most desirable in a gelatine for collotype work are freedom from foreign bodies of any kind and the property of withstanding long immersion in water without either spontaneously becoming liquid or absorbing a very great quantity of water. There are various gelatines in the market which are specially sold as suited to collotype work, and doubtless any of these got from a respectable dealer will serve the required purpose.

Albert, who must be heard with respect on all matters pertaining to collotype, has the following remarks on the choice of a gelatine for the particular work we are considering:

Gelatines of excessive hardness and of excessive softness are both ill suited to collotype work; the hard gelatine giving a film which soon breaks up in printing, the soft gelatine giving a plate from which vigorous impressions cannot be obtained. He recommends the use of "middling hard gelatine," and mentions a special brand, that of F. Creutz, of Michaelstadt, Hesse, as particularly good.

He gives the following means of discovering whether a gelatine is suitable for collotype work as regards hardness: Two portions of it are made up, one with bichromate of potassium (either of the two formulæ to be presently given may be used), the other with bichromate of ammonium, substituted for the bichromate of potassium. Plates are coated with these solutions, and are dried at 120° Fahr. If they both show a polished surface, the gelatine is too hard. If they both show a matt surface, it is too soft. If that prepared with bichromate of potassium shows a matt surface, that with bichromate of ammonium a polished surface, the gelatine is of the right hardness.

It may be taken then that if a gelatine is free from foreign substances, if it shows a good result when the test just described is applied, and if it will bear soaking for forty-eight hours in water at a temperature of 60° Fahr., it is suitable for collotype work.

THE ALBERT-TYPE.

The above name has been given to Albert's process. As some may like to give it a trial, I give briefly one of several modifications of the process which have been published:

A.

No. 1. Hard gelatine	⅛	ounce.
Water	6	ounces.
No. 2. Bichromate of potassium	¼	ounce.
Water	6	ounces.

The gelatine is soaked and melted in the water with heat, and solutions 1 and 2 are mixed.

B.

Albumen ..... 6 ounces.

This is made from fresh eggs, is beaten into a froth, and is then filtered.

C.

No. 1. Collotypic gelatine	1	ounce.
Water	12	ounces.
No. 2. Bichromate of potassium	80	grains.
Water	1½	ounces.

The gelatine of No. 1 is soaked in the water and melted by heat, and Nos. 1 and 2 are mixed together.

A is filtered through cambric at a temperature of about 120° Fahr. It is allowed to cool to about 100°, and B is added to it. The mixture is kept at a temperature not exceeding 100°, and the glass plates, previously carefully cleaned as if they were to receive a collodion film for the wet process, are coated thinly with the solution. They are laid on a level slab till the gelatine has set, and are then dried in the dark at an ordinary temperature. When the film is dry, the plate is laid face downward on a piece of black velvet, and is exposed to light till the color changes from a bright yellow to a dark brown. It is then very thoroughly washed in warm water till the color is entirely removed. The plate is now ready to receive the final coating, but may be kept almost indefinitely if it be desired.

C is now heated to a temperature of about 150°, and is filtered through two thicknesses of cambric. Such plates as it is desired to use, already coated with the substratum as described, are raised to about the same temperature as the solution (150°), and are coated, the thickness of coating given being somewhat less than would be given to a dry plate. They are then placed in a horizontal position in the drying cupboard, the temperature is raised to about 140°, and is kept at that till the films are dry. The plates may be used whenever they are dry, or may be kept in a cool, dry, and of course dark place, for several days if it be desired.

Printing under the negative is done just as described for Husnik's process. After it is over, the films are submitted to a long continued washing to remove the whole of the bichromate; they are then dried and are ready to be printed from.

HUSNIK'S PROCESS.

I have given the above name to the process of collotype now most commonly worked, because I believe Husnik was the first to publish the distinguishing feature of it, namely, the use of a substratum of water glass and albumen on a ground glass surface. If he was not the first actually to publish it, he was certainly the worker who had the chief influence in popularizing it. I have gained much assistance in my investigations in this process from the publication of Schnauss on *Collotype*.*

A.

Albumen (switched)	8	ounces.
Commercial water glass solution	3½	"
Water	10	"

B.

1. Collotype gelatine	1	ounce.
Water	12	ounces.
2. Bichromate of ammonium†	80	grains.
Water	1½	ounces.

The water glass solution in A should be of the consistency of sirup. The three ingredients are mixed, and are switched into a froth either by the aid of an American egg-beater or by placing the mixture in a bottle with pieces of broken glass and violently shaking the bottle. The froth is then poured on the filter paper. The fluid which passes through is preserved.

To prepare B the gelatine is allowed to soak in the water for about an hour, when it is melted by the aid of heat; solution No. 2 is then added. The whole is now filtered through a double thickness of cambric, when it is ready for use.

The plates are ground on one surface as already described. They are carefully cleaned, and are then coated with solution A. This flows readily over the surface. As much excess as possible is poured off, and the plates are dried in an inclined position at the ordinary temperature of the operating room. When dry they are thoroughly rinsed, and are once more dried. In this condition they will keep almost indefinitely. When it is required to use the plates, they are coated with solution B in the following manner: Such plates as are required are heated to a temperature of about 140° Fahr., and the solution is heated to the same point. A plate is taken in the left hand, and is balanced on the tips of the finger and thumb, a card mount being placed under it if it be found too hot for handling. A pool of the solution is now poured on the upper surface—that with the substratum, of course—and the plate is quickly tipped, so that some of the solution is poured off at each corner. The plate is now rocked slightly, so as to cause the liquid to spread itself in a perfectly even film, and is immediately placed in the drying box. It is impossible to say precisely how much solution should be left on the plate; but it may be said that if the thickness of the film be right, the drying, at a temperature of 120° to 140° Fahr., with a good supply of air, will take about an hour.

Unless reversal of the final prints is permissible, it is necessary to have reversed negatives to print from. There are various ways of producing these. The first and best, where it is possible, is to use a mirror or prism as a reflector in front of the lens of the camera. Another is to expose in the camera *through* the glass. It is unnecessary to say that if this expedient be had recourse to, the back of the plate must be cleaned very carefully. The method of reproducing by the powder or "dusting on" process has already been mentioned.

I am aware that some photo-mechanical printers produce reversed negatives by taking advantage of the fact that a very long exposure produces, in the case of a dry plate, a reversed action of light, so that giving a gelatino-bromide plate a very long exposure in contact with a negative, a negative is the result on development. I have seen excellent results produced in this way, but must confess that my own experiments have not been very successful. A roundabout way in which to produce a reversed negative is to make, from the original negative, a transparency in the camera, turning the back of the negative toward the lens, and to make a negative by contact from a transparency.

In the days of wet plates, it was a common thing to strip the film, which must not be varnished, from the plate, when exposure might of course be made in the printing frame, so as to give an image direct or reversed, as might be desired. The method of stripping is as follows:

Gelatine	3 ounces.
Glycerine	1 ounce.
Water	15 ounces.

The gelatine is soaked in the water, is melted with heat, and the glycerine is added. This composition is poured over the film of the plate and is allowed to dry, when the double film of collodion and gelatine may be stripped away. I believe that stripping is not commonly resorted to in the case of gelatine dry plates, but it is quite possible to do it, Plener having indicated how it may be done. The film is coated with the solution given above. It is then hardened by allowing it to soak for ten minutes in a saturated solution of chrome alum, is thoroughly washed in cold water, and finally left to soak for half an hour in a twenty-five per cent. mixture of glycerine and water. The surface moisture is blotted off with blotting paper, the film is dried, and the plate is placed in a weak solution of hydrofluoric acid. This in time soaks through the film, dissolves away the surface of the glass, and causes the film bearing the negative to float away from the plate. The film is now squeegeed down to a sheet of vulcanite to dry.

As regards general quality of a negative for collotype work, it may be said that one which is suitable for silver printing will also serve well for collotype.

It is advisable to use a collotype plate which will allow an inch of margin all around the negative; and this margin is protected from light by an opaque paper mask glued to the edge of the negative and to the plate glass of the printing frame. Special frames are made for collotype work, but an ordinary frame with plate glass front may very readily be adjusted so as to take the extra thickness of the plate glass bearing the gelatine film.

The collotype plates are ready to be printed from whenever they have cooled after coming from the drying box; but they may be kept for several days in a cool, dry place, carefully protected from light, of course. It may be well here to say that, in all the manipulations of collotype plates, from the coating to the washing after exposure—to be afterward described—about the same precautions against actinic light should be taken as in the case of albumenized sensitized paper. It is well to take this precaution even when the plate is wet, although in this condition it is by no means so sensitive as when it is dry.

The plates *may* be kept for several days before they are used, and some prefer so to keep them, considering that better results are to be obtained from plates that have been kept for some time than from those that are quite new.

The plate is exposed behind a negative in the usual manner, and the progress of the printing is observed from the back through the glass. The exposure is sufficient when the details of the high lights just begin to be visible. The color of the image is a light brown on a bright yellow background.

The exposure over, the plate is laid film side on a piece of black velvet, and a certain exposure is given from the back. It is difficult to tell exactly how long this exposure should be; but it may be said that if a piece of sensitized albumenized paper be exposed alongside of the plate, the latter will have had exposure enough when the paper has become dark chocolate color. In high diffused light (not direct sunlight) five to ten minutes will be found to be long enough.

* *Der Licht Druck und die Photolithographie.* Von Dr. Julious Schnauss. Dusseldorf, Ed. Liesegang's Verlag.

† Albert recommends the use of bichromate of potassium rather than bichromate of ammonium, stating that many of the troubles which crop up in collotype work are due to the use of the latter salt.

DEVELOPMENT OF THE PLATE.

The plate is developed merely in cold water. Whenever it is placed in the water, a curious change takes place—the image shows in a certain relief, the high lights swelling up, at the same time the whole of the film, except those parts representing the deepest shadows, develops a fine grain of the nature of a *reticulation*. This grain should be so fine that it is barely visible to the naked eye.

The development is continued by washing the plate with continuous changes of water till the last trace of bichromate is washed from the film, as indicated by the complete absence of color in the washing water. The image will now be all but invisible but by reflected light, showing the relief, the image by transmitted light being of a very faint brown color.

The plate is now laid for one hour in a one per cent. solution of alum, is again thoroughly washed, is surface-dried with blotting paper, or is soaked for five minutes in a bath of spirit, and is reared up to dry. It is well, if possible, to allow two or three days before the plate is used for printing, although it may be put in the machine whenever it is dry.

PRINTING FROM THE PLATE.

To *teach* collotypic printing to one quite unpracticed in that or any analogous descriptions of printing merely by giving instructions is a thing that is quite impossible. A skilled lithographic printer, if the manipulations of collotype printing be described to him, will very soon master the more delicate process; the operator who is ignorant altogether of printing can expect to become expert only by long practice. His labors will certainly be greatly facilitated if he can get a printer already skilled in working collotype to help him.

The principles involved in collotype printing are the same as those in lithographic printing, but the process is in every way more delicate than the ordinary run of lithographic work.

The ordinary lithographic press may be used for collotype printing; but presses are made specially for the latter process, which are better suited than lithographic presses for the special work for which they are designed.

There is no gumming or etching in collotype printing, as in lithography. The plate is simply damped, inked, and passed through the press; but in damping it is a common practice to add to the water some deliquescent substances, which prevent evaporation and make it unnecessary to damp the plate again till a considerable number of prints have been pulled. This treatment with water and deliquescent substances is commonly termed *etching*, although the name is really a misnomer.

A quantity of this "etching fluid" may be made up as follows:

Water	12 ounces.
Glycerine	1 pint.
Common salt	30 grains.

Or two parts of water may simply be mixed with three parts of glycerine.

The plate is left for two hours in this solution, is surface-dried with blotting paper, and is fixed to the bed of the press. If it be left wet on the under side, it will fix itself with sufficient strength without further cement of any kind, but it is common to fix it down with plaster of Paris.

The outer edge of the plate is protected with a mask of paper, so arranged that it can be lifted away before inking and be replaced afterward. This is to secure perfect whiteness of the margins.

The ink is made up like lithographic ink, but it is commoner to use brownish or purple colors in place of black. It is also customary to use two thicknesses of ink, with two inking slabs, and two rollers. The thicker ink is applied first. It takes on the deepest shadows, only giving them strength. The thinner ink is next used, and brings out the finer and more delicate details without harming the shadows.

The paper used for large work is generally good quality sized printing paper. It is made slightly damp before use. For small and very fine work chalk-surfaced paper is used without damping. After a dozen or so of impressions have been pulled, or before that if the high lights show any indication of taking ink, the surface of the film is damped with the etching fluid. Some prefer to damp with plain water in place of a deliquescent fluid. In this case it is necessary to damp after each impression, a damping cloth being used.

It must always be borne in mind that an indefinite number of prints cannot be expected from one collotype plate. There are, it is true, exceptional cases when the weather is cool, and when all other circumstances are favorable, when thousands of copies may be pulled from one plate; but in average circumstances only a few hundreds can be expected, and there must be no disappointment if the film break down after a few dozen prints have been produced. Taking these circumstances into consideration, it is desirable to make, in the first place, a number of collotype plates, if a very large number of prints be desired.

The prints are varnished or are left unvarnished according to the taste of the public for whom they are produced. Husnik recommends a varnish consisting of one part of gum mastic and two parts of shellac dissolved in alcohol. Frequently a water varnish, made by dissolving shellac in a hot solution of borax, is used.

PRINTING BY MACHINE.

Concerning machine printing of collotype, it is unnecessary to do more here than state that machines are now commercially produced for the purpose of collotype printing, capable of turning out several thousand impressions in a day, and that these machines in skilled hands give excellent results, the plates, according to Mr. E. Edwards, lasting better under them than under hand presses.

THE HELIOTYPE PROCESS.

The process to which the above name has been given will be understood by the aid of a very brief description, if the process of Husnik be first mastered. Heliotype differs from other collotype processes in that the sensitive film before exposure is separated from the glass on which it is prepared, is manipulated as a film, and is then cemented down to a pewter plate for development and printing.

Formulæ—

A.*

Gelatine	1½ ounces.
Glycerine	1 drachm.
Water	12 ounces.

B.

	In Summer.	In Winter.
Bichromate of potash	22 grains.	30 to 40 grains.
Chrome alum	15 "	7 to 15 "
Water	12 drachms.	12 drachms.

Glass plates are ground on one side and are waxed, by pouring on to the ground surface a solution of white wax in ether, and afterwad polishing off as much as possible with a clean cloth. The plates are now heated, and the wax sides are coated very thickly with the solution made up by mixing A and B, and raising it to a temperature of about 140°. About as much solution is poured on to the plate as will lie on it without spilling off at one edge or another. Drying is now performed at the comparatively low temperature of 75° Fahr. When the films are dry, they may readily be stripped from the glass.

The *ground* or grained surface of the film has now to be exposed by placing it with the smooth surface on a piece of black velvet, and allowing the light of the sun to act on the other side.

The exposure must be continued till the action of the light has just penetrated the film. To gauge the exposure a small portion of the film is cut away, and a mask of opaque paper with a small hole in it is made to cover this small fragment of film. The film covered with its mask is now placed under one edge of the film which is being exposed. Whenever the image of the hole in the mask appears visible in the film under it, the exposure is sufficient. The smooth side of the film is now exposed under a negative in the manner already described for Husnik's process.

A polished pewter plate somewhat larger than the film is now coated with a solution of rubber in benzole—a strength of five or six grains to the ounce being a suitable one. The film is allowed to set, the plate is placed in water, the film is brought with its grained side into contact with the rubber film, the plate and film are removed from the water together, and the film is firmly squeegeed down. The film is edged with rubber solution to prevent water from penetrating, after which the plate is developed by washing with water till all bichromate has been washed from the film. The surface of the skin is dried with blotting paper, after which printing may begin at once.—*Burton's Guide to Photo-Mechanical Processes.*

* Abney's *Instructions.*

IMPROVED FUSIBLE PLUGS.

THE accompanying illustrations show two forms of fusible plugs for steam boilers, placed upon the market

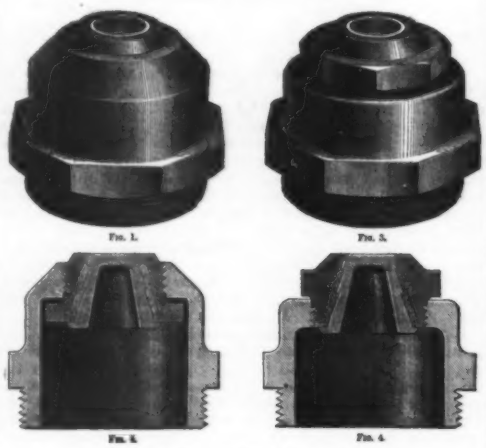


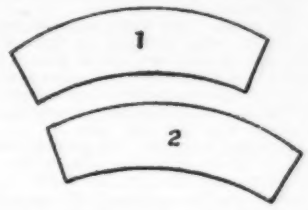
FIG. 1. FIG. 3. FIG. 2. FIG. 4.

IMPROVED FUSIBLE PLUGS.

by the National Boiler Insurance Company, of No. 22 St. Ann's Square, Manchester. Figs. 1 and 2 represent a full sized section and general view of the "improved screw cone" plug, and Figs. 3 and 4 show the "improved valve seated" plug. It will be seen that they are constructed on the well known double cone principle, which has the special advantage of non-liability to partial fusion—a serious defect found in some plugs. It is found in practice that if a small hole is formed, which permits steam to pass even in a small jet, fusion is immediately checked, and the opening being small, there is no action on the fire, nor a sufficient rush of water to attract attention, and thus the boiler may be seriously injured or an explosion occur. In the "improved double cone" plug the inner cone, C, fills the opening in the plug like the stopper of a bottle, being secured in position by the fusible metal. Should the boiler become short of water, this metal melts and releases the inner cone, and on this being blown out a large, clear opening is secured, through which the steam and water can rush upon the fire and extinguish it, thus preventing any further damage. The entire detachment of the inner cone and a large, clear opening are insured by the so-called "protector flange," which not only protects the fusible metal from deterioration by the furnace gases, but in case of fusion of the plug prevents the escape of the metal until it is entirely fused, when the cone is at once detached and blown out as previously described. By referring to the illustrations, it will be seen that all the details which have been found valuable have been retained; but the construction has been simplified, and efficiency more certainly insured. The chamber, P, below the cone is free from anything which might obstruct blowing out, and the general arrangement is such that no ordinary deposit from the furnace can interfere with the action of the plugs. In the "screw cone" plug (Figs. 1 and 2) the cones are inserted from the inside of the furnace, and in the "valve seated" plug (Figs. 3 and 4) from the inside of the boiler, in both cases with a minimum of trouble, no cement or packing of any kind being required to secure a tight joint.—*Industries.*

CURIOUS OPTICAL ILLUSION.

THE accompanying figure represents two pieces of paper or cardboard cut into the shape of arcs of a circle. Which is the larger of the two? To this the answer will certainly be: "It is No. 2." But if No. 1 be placed



under No. 2, the answer will be just the reverse. The fact is that both are exactly of the same size, as may be seen by measuring them, or by laying one upon top of the other. When the two figures are placed so close together that their edges touch, the illusion is still greater.—*La Nature.*

A SIMPLE SPECTROSCOPE.

By A. F. MILLER.

IT is proposed to give the results of some experiments having for their object the designing of a small spectroscope, which, while constructed from such simple materials as practically set aside all question of cost, can also be readily and easily put together in a short time, without the assistance of a lathe or tools other than the commonest, and yet will be found quite adequate for the demonstration of the chief facts of spectroscopy and for the successful performance of a number of interesting and instructive experiments in this most wonderful department of physics. No youth engaged in the study of chemistry should be without such a simple and yet effective assistance. No teacher should longer vaguely descant to his pupils upon the principles of spectroscopic analysis unillustrated by example, when a method for practical demonstration is brought so easily within his grasp. The Fraunhofer lines, the bright lines of metallic spectra, the absorption bands of vapors or liquids, are too often classed among the phenomena only capable of exhibition by the elaborate appliances of the physical laboratory or, at least, by the aid of somewhat costly and complicated apparatus, and, therefore, while nearly every student of science has a nominal acquaintance with them, so far as practical knowledge is concerned they are, to too many, a veritable *terra incognita*. It is one thing to read or hear of such matters, quite another to *see* them. Indeed, it is well within bounds to assert that one view of any of the phenomena just mentioned, though obtained by a spectroscope no more powerful than that to be presently described, will impart more real understanding and appeal more surely to the mind than the perusal of a whole volume or the hearing of an elaborate dissertation when no experimental demonstration is made.

In proceeding to describe the construction of our instrument, the simple materials for which may be obtained almost anywhere, its different parts, as shown in Fig. 2, will first be enumerated:

There must be a body tube, A; a focusing tube, B; a slit, b^2; a collimator, a^1; and prism, a.

For the body tube, A, a four inch length of brass tube will be required, which may have an internal diameter of a little over one-half inch. The focusing tube is a piece of smaller sized tube capable of slipping easily into the former. It may be three inches long. Both tubes should be dead-blackened inside, as pointed out in a previous article.* The sliding joint is conveniently made by wrapping round the focusing tube a strip of black broadcloth, a^3, which is then secured in one end of the body by means of a little warm acetic glue. The slit may be, to quote the trade term, either "non-adjustable" or "adjustable." The former is, of course, by far the simpler, and, while not the most convenient for all purposes, will best suit the wishes of some who may desire to carry out the whole instructions by the aid of a file and a pocket knife. Accordingly it has been figured, and will first be treated of.

A one-eighth inch slice, b^1, is to be cut from a sound cork of such diameter as just tightly to enter the focusing tube, and centrally perforated with a one-eighth inch hole. A disk of thin sheet zinc or brass, b^3, is cut of just the same size as the cork. This disk is marked across by a central line and divided there by a cut with a sharp pair of scissors. The two edges produced in this way are next worked with care on a fine slate moistened with water, so as to remove any burry edge the scissors may have raised. In working these pieces or "jaws," they should be held slantingly and moved alternately sideways and crossways, so as to keep the edges true and impart to each a beveled or chisel-like form. A surface of the cork having been smeared with warm acetic glue, the jaws, b^3, are laid thereon and carefully adjusted with the point of a needle till only the finest possible line of light, unblurred by roughness of the edges, is apparent between them. When the glue has hardened, the slit is complete, and is secured by a trace of glue in the front of the focusing tube, preferably as shown, a little inside its extremity, that this, by projecting beyond it, may serve to protect the jaws, which otherwise might be knocked off.

An adjustable slit is somewhat more troublesome to construct, but, it must be confessed, it is also much more convenient. If such an appliance be desired, a disk of ⅛ in. sheet brass, about ½ in. in diameter, must be filed out and drilled with a central hole which the focusing tube can just barely enter, thus forming an annulus or band; a disk of the same material is also made just entering the cavity of the focusing tube, where it is secured by soldering, and drilled with a central ⅛ in. hole. The outer part of the focusing tube must then be cut with a tapering screw thread for a distance of ¼ in. and the annulus tapped inside to

* SCI. AM. SUP. No. 651.

screw upon it. With a fine hacksaw, a slot is next cut centrally into the end of the focusing tube, dividing it to a distance of ½ in. and, of course, cutting in two the disk soldered within it. Two brass jaws made as already described are soldered down, one on each half of the disk, their knife edges being almost in contact over the central hole; the slot is then slightly sprung open and the annulus screwed on. As this is tightened the jaws approach one another, as it is relaxed the springiness of the tube causes them to separate. The chief difficulty will be found in getting the jaws true when soldering, but a failure in this respect at the first or even the second attempt involves no great loss and should not discourage the student, who, by care and patience, will soon assure his own success. The adjustable slit is shown in Figs. 7 and 8, which are drawn to an enlarged scale. The rest of the figures are of the exact size. Behind either form of slit must be placed a diaphragm of black card having a $\frac{1}{16}$ in. central hole. This is shown at b^3, and a good way to fix it in place is by the aid of thin ring of cork, b^4.

The collimator, a^1, is made from a spectacle lens of 5 in. focus reduced on a grindstone till it will just enter the body, at the end remote from the focusing tube; it is inserted as shown to a distance of rather less than ½ in. and secured in place between rings of black card.

We are now ready for the prism, *a*, and since on the goodness of this the whole value of the instrument is dependent, some particular directions as to selection and preparation are necessary. It is made from a section cut from one of those triangular crystal pendants which serve as ornaments to lamps and gasaliers. In choosing a pendant at the lamp dealer's (where generally access may be had to a whole boxful of odd or damaged ones), the point first to be noted is that the lines of the angles *must be parallel*, a tapering prism being quite useless; next the greatest angle of the triangle should not much exceed 78°, the side opposite to it being about ½ in. across. Using this angle as the refracting one, and examining through it, with the aid of the finished collimator and slit, light from the sky or a bright cloud, it will be easy to judge whether the prism is suitable. If a clear, narrow band be visible, having the spectral colors in proper order, above all, if there be seen some of those narrow dark *vertical* lines called "Fraunhofer's lines," then all is well; but should a confused image be formed, wherein different spectra appear to overlap or show one behind another, such a glass must be rejected as useless for our purpose. In practice, I have found no difficulty in obtaining good material. Six luster drops, selected almost at random, by eye estimation of the straightness of their sides, gave, when tested, the following results: 3 very good, 2 moderately good, 1 unsuitable. In fact, the method adopted in the trade for polishing these pendants very often gives a degree of accuracy quite surprising when its simplicity is taken into account; and a well selected prism of this sort will give far better results than the ordinary equilateral flint glass ones sold by the opticians for projective spectra and such like experiments. But the luster prisms have another and signal advantage for our purpose, due to their possessing one angle so great as say 78°; whereas the opticians' common prisms have none greater than 60°.

Now, though in spectroscopy it is not usual to employ a simple prism of greater refracting angle than the latter, yet, owing perhaps to the fact that the "metal" employed for the luster drops is not very dense, the large angle may safely be used, and will be found to greatly increase the dispersive power. From a well-selected glass of this kind may be cut a prism capable of giving a dispersion not greatly inferior to the compound trains used in the small French direct vision pocket spectroscopes usually sold for about $10. Having then observed due precaution in choosing and testing our glass, we may proceed to cut the prism of a length equal to the internal diameter of the body tube. To do this a new and moderately fine file will be necessary; with its point guided by a straight edge, a scratch is made on each side of the glass; then a notch is boldly filed into each angle, and a moderate pressure of the thumb and finger snaps off a neat little prism, the breakage generally following pretty accurately the scratched lines, though slight deviation therefrom matters but little. With a view to further experiments, the pendant may be cut into as many prisms as its length will allow, and the best selected to undergo the operation of grinding down to fit into the body tube. This is readily effected by means of a grindstone, kept well moistened with water and run slowly; the sharp edges left by breakage at the upper and lower parts *toward the greatest side* are well rounded off in this way, so that the little prism assumes almost the form of a capital D (see Fig. 5), the grinding being continued till it is reduced enough to loosely enter the body tube in the vacant space behind the collimator. Its mounting is effected by means of a narrow slip of fine black broadcloth; this is doubled, so as to turn in the raw edges, and wrapped over the prism, *a*, as shown in Fig. 2, traversing and *covering* the greater side, and extending down the refracting angle, where by preference an extra thickness of cloth is placed, so as to push the prism well into the curve of the tube, care of course being taken not to cover the two sides adjacent to the refracting angle, since through these the light is to pass. The cloth band is held on the prism by a few stitches securing the end of the strip, and a little glue applied to the ground surfaces before the wrapping holds it very securely. The prism is now introduced into the body behind the collimator, approximately in the position figured, the refracting edge being kept parallel to the slit. If the prism has been ground as directed and the cloth band is of suitable thickness, the proper position will be almost naturally assumed, but it may easily be rotated a little in its bearings till the spectrum can be perceived when by experiment the proper degree of inclination may be determined, preferably by daylight, the clearness of the Fraunhofer lines being the most useful test. It is necessary here to work to a certain extent by "rule of thumb," and by several trials obtain the best result. The cloth band should fill the body all round the prism, so that no stray light may pass. Previous to inserting the prism finally, a small quantity of sealing wax should be melted at two or three points in the extremity of the body, so that by holding this for a moment in a spirit lamp flame, the wax, being softened, may adhere to the cloth band and fix the prism in adjustment. Should subsequent removal become necessary, the wax may of course be softened again.

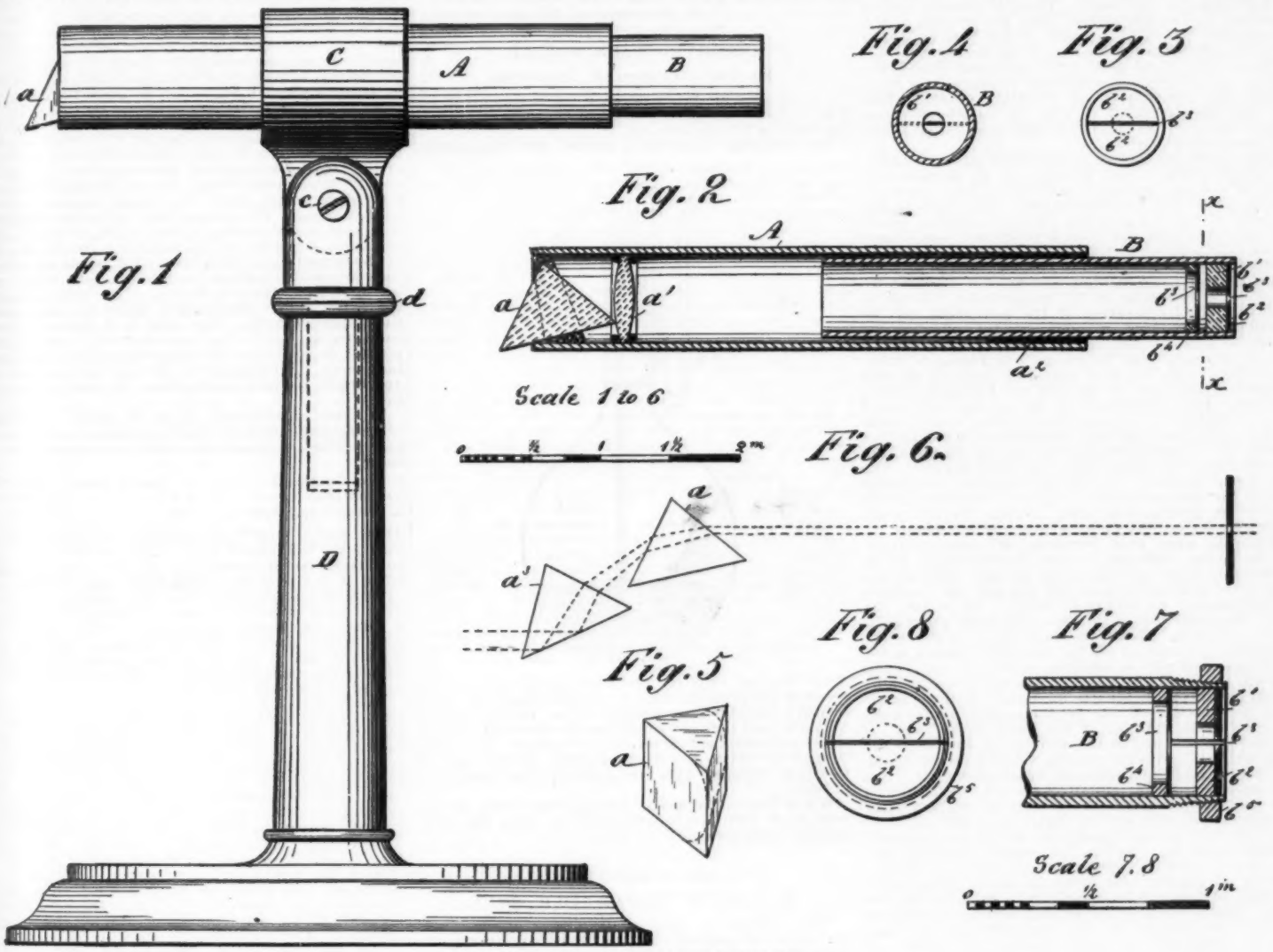
The instrument is now practically finished, and its capabilities are much greater than any one inexperienced in its use can suppose. It may be objected that oblique vision is necessary, but a very little practice will give such familiarity with the proper position for the eye that no difficulty will arise from this cause. There is indeed an easy method of obtaining what really amounts to direct vision with such an instrument, by the use of a second small prism cut from the same glass. Owing to imperfections of the surfaces and want of homogeneousness in the material of so cheap a nature, the introduction of another prism tends somewhat to mar definition, and therefore the following method is not recommended; but since it serves admirably as an illustration of certain functions of the prism, the student may well try it if only as an interesting optical experiment. In Fig. 8, then, *a* is a prism traversed by rays which are supposed to take the course of the dotted lines from a slit, S; then an observer's eye at O^1 would perceive a spectrum. Instead of so placing the eye, let a second prism, a^2, be introduced in the position indicated; then the rays emergent at O will enter and traverse a^2, suffering total reflection at its inner surface, *i*, and will emerge at O^{11} practically in a line parallel with their first course. Thus, by the addition of the second prism, it becomes possible for the observer's eye to be directed straight toward the source of light, instead of obliquely. As before remarked, a loss of definition is pretty sure to attend this method, for the reasons already stated, but the experiment is interesting and the result a surprise to any one not thoroughly versed in the action of the prism. A little projecting hood of sheet brass or tin soldered to a ring of similar material, of a size to slip on the end of the body, may be provided to hold the second prism when direct vision is desired, and at other times this accessory may be removed.

The finished instrument should have a stand, and that sketched in Fig. 1 will be found very convenient. It is supposed to have a joint for horizontal motion at *d*, and another for vertical motion at *c*, the latter being made from a piece of sheet brass, working in a saw notch in the wooden top and secured by a wood screw; while the spectroscope slips into a clamp of sheet brass lined with cloth sprung in to grasp the body, and united by solder to the vertical motion joint.

The various parts are so simple as to require no further explanation. Should it be inconvenient to obtain turnings, the whole may be "whittled" out, and, if less ornamental, will be quite as efficient. A paper case, with pull-off top, is also easily made, and enables the instrument to be carried in the pocket, when it will often be found of much use.

The foregoing being intended mainly for beginners in spectroscopy, it may not be out of place to refer briefly to a few of the many experiments readily performable by this simple means.

As already stated, the chief Fraunhofer lines in sunlight reflected from the sky, or from a bright cloud, are very easily seen, and, by the aid of a small chart of the solar spectrum, may be identified and their names memorized. Several of these lines will also be recog-



A SIMPLE SPECTROSCOPE.

nized in the light of the moon. The telluric bands, which originate in absorption of solar rays during their passage through the earth's atmosphere, will frequently be perceptible, and in this way the prediction of approaching rain is often possible. The bright lines in the spectrum of lightning may sometimes be observed, as well as those that characterize the aurora. By the aid of a spirit lamp, or, better, of a Bunsen burner, the beautiful and varied flame spectra afforded by salts of lithium, strontium, calcium, barium, potassium, and sodium can readily be produced, and, where a small induction coil is available, a whole host of further experiments, as beautiful and varied as they are interesting and instructive, becomes possible. Specially charming are the spectra of such gases as hydrogen, nitrogen, and carbonic oxide, when transmitting the electric discharge. Nor must we overlook the curious absorption bands and lines which appear when the rays from a lamp flame pass through such deeply colored vapors as hyponitrous acid, iodine vapor, etc. The aniline dyes in solution, blood, and other colored liquids give interesting appearances by the same method; nor should different varieties of colored glass be forgotten, especially the various shades of blue.

PETROLEUM AS AN EXPLOSIVE.

By Prof. PETER T. AUSTEN.

WHEN an oil train suffers a collision, it is a common occurrence for the oil to take fire. If the accident happens as the train is passing through a city, much loss of life and property may result. These oil fires are usually explained by the assumption that the ignition of the oil has been caused by a spark struck from impact of metallic surfaces or by live coals from the locomotive.

The amount of oil passing through some cities is immense, and terrible calamities may happen at any time, should the contents of an oil train suddenly flow through the streets of a town in burning streams. Should this occur at night, it is hard to say what nameless horrors might result.

That petroleum evolves inflammable gases at ordinary temperatures is well known. As to its inflammability at low temperatures, however, I have been unable as yet to find any information. As petroleum is a mixture of varying amounts of hydrocarbons, which run from very light and volatile substances to solid and heavy ones, and as certain of these lighter and more volatile hydrocarbons seem to be gases held in solution in the heavier hydrocarbons, and are not liquefied by considerable reduction in the temperature, it is fair to infer that the temperature of the petroleum may be considerably reduced without greatly affecting its power to evolve inflammable gases. To test this, a sample of crude pipe petroleum was placed in a six-ounce flask to the depth of about an inch and allowed to stand in a mixture of ice and salt for about twenty minutes. The temperature of the oil was then found to be 0 degrees F. On applying a small flame to the mouth of the flask, the flask at once became filled with a blue flame. The flask was allowed to cool for about ten minutes, and then shaken and the flame applied. The flash again occurred. The fact is therefore established that at the temperature of 0 degrees F. crude petroleum evolves an inflammable gas. In this respect, then, petroleum is dangerous both in summer and winter.

When the gases from petroleum are mixed with air, the gas having sufficient oxygen mixed with it for its combustion when ignited, burns at once, and, as the heat of combustion expands the gas, air, and products of combustion, an explosion results. Of course the more the petroleum is agitated, the more gas will be evolved from it. Hence the iron tanks in which the petroleum is conveyed on the cars must contain in the parts not filled with oil an inflammable gas, and as this gas will be mixed with more or less air, it will be more or less explosive. If the gas in contact with the petroleum becomes ignited, the petroleum will in most cases take fire unless the body of the liquid is very cold. If it takes fire, the heat of the combustion soon heats the body of the oil, thus causing the whole mass to boil up and evolve large quantities of inflammable gas. It is also possible that the tanks from which the petroleum has been emitted may be filled with an explosive gas. In case the oil tanks are but partly filled with oil, their condition will be more dangerous, as the agitation will liberate more gas. As the temperature increases and the oil in the tanks becomes warmer, both the oil and the gas will expand, and, unless the tanks are absolutely tight, the gas will be forced out by the internal pressure. Should the gas thus issuing become ignited, say by live coals dropped by the locomotive, or hot bearings, the tank may assume a dangerous condition. It seems, therefore, that under certain conditions petroleum may be considered as belonging to the class of explosives that explode on application of heat alone, as gunpowder, for instance.

The behavior of a tank of petroleum under pressure does not seem to have been much studied. It is a well-known fact that if a volume of air be compressed by means of a cylinder and piston, the motion of the piston is converted into heat. The physical apparatus known as the "fire syringe" is an example of this. On the end of a brass piston, working snugly in a brass cylinder closed at one end, is a piece of tinder. On driving the piston in by a powerful and sudden blow, and then withdrawing it, the tinder will be found to be on fire. That is to say, the compression of the air has raised its temperature to a point sufficiently high to ignite the tinder. If the fire syringe is made of glass, as it often is, so as to allow the ignition to be readily seen, it will be noticed that not only is the tinder ignited, but also the oil with which the piston was lubricated. The burning of the oil causes a bright light at the moment of maximum condensation, and proves that the temperature must be at least 300 degrees. Of course, the temperature required for the ignition of the volatile gases of petroleum would be less than would be required to ignite an average lubricating oil.

The amount of heat developed by the compression of a volume of air to one quarter of its volume will be the same as is required to expand one volume to four volumes. Assuming the temperature of the air and vapor over the petroleum to be 0 degrees F., the elevation of temperature on compressing the space to one quarter will be 499 degrees. Taking the temperature to be 70 degrees F., the rise of temperature will be 499 degrees.

It follows, therefore, from the above that if an oil tank filled partly or entirely with an inflammable mixture of petroleum gas and air be suddenly compressed in such a way as to greatly reduce its volume, the gas, beyond a doubt, will be ignited by the compression, and in all probability will ignite the contents of the tank. Such a compression might result from the oil tank being "telescoped," or falling from a height to the ground below.

If an oil tank almost entirely filled with oil were suddenly compressed, the resistance offered by the liquid would heat the latter sufficiently to cause it to evolve the lighter hydrocarbons which it contains; and even if they were not ignited by flame or spark struck by metallic friction, they might be set free in such amounts as to produce a dangerous pressure within the tank, especially if the tank were in a weakened condition. The sudden stoppage of an oil tank car but partly filled with oil, as would occur in case of a collision, would cause the mass of oil to be hurled with great force against the front end of the tank, and in this way enough heat might be generated to evolve an amount of gas sufficient to cause the tank to become dangerous.

From these considerations it appears that there is no doubt but that petroleum may be considered as capable of ignition by impact, and when once ignited causing an explosion. It is, therefore, a question if petroleum should not be handled with the same or similar precautions that are taken in the transportation of substances explosive by percussion, or impact, as a nitroglycerine, for instance.

Rutgers College and N. J. State Scientific School.

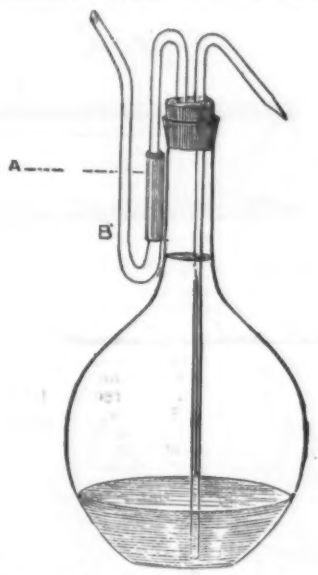
—*Engineering and Mining Journal.*

IMPROVED WASH BOTTLE.

By Prof. GEORGE W. SLATTER.

I HAVE used an improved wash bottle which I think will be found useful to analytical chemists and others for washing precipitates, etc.

The annexed drawing is almost self-explanatory.



After blowing with the mouth as usual until a good pressure has been obtained within the flask, the India rubber tube may be squeezed by the thumb against the neck, and then the mouth may be removed, but the water will continue to stream out of the jet. The tube, B, may be tied to the flask by string, and the neck of the flask wrapped with string or other bad conductor of heat.

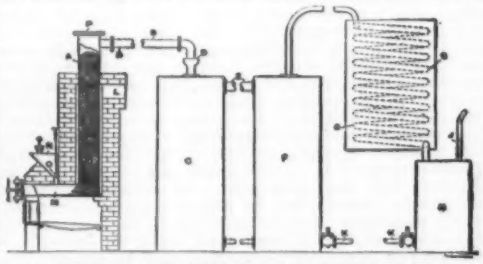
When the bottle needs refilling, the India rubber tubing, A, will stretch sufficiently to allow the withdrawal of the cork.—*Chem. News.*

CARBON BISULPHIDE.

By ROWLAND WILLIAMS, F.I.C., F.C.S.

THIS substance occurs naturally in crude benzol and in oil of mustard. It is a heavy, colorless liquid, with very great refractive powers. When perfectly pure, carbon bisulphide has a faint ethereal odor; but the crude article possesses a most disgusting smell. Carbon bisulphide is slightly soluble in water—about one part per thousand. Its vapor is highly inflammable and very poisonous, and when inhaled produces most unpleasant and even dangerous symptoms.

Manufacture.—Carbon bisulphide is made on the commercial scale by passing sulphur vapor over red hot charcoal, which is contained in retorts, as at A, in



GENERAL VIEW OF MANUFACTURING PLANT.

the above illustration. The retorts are made of cast iron, about 1½ in. thick, with an extra thickness at the bottom. They are cylindrical in shape, and measure about 16 in. diameter and 12 ft. in length, and are set in brickwork in a vertical position. Fire clay retorts are not used on account of the extensive wear and tear which would take place. The outlet for the carbon bisulphide vapor is a cast iron pipe, B, about 6 in. diameter, and is situated close to the top of the retort, A. This pipe is connected with an iron boiler, C, about 12 ft. by 5 ft., by means of ordinary water lutes, D. A portion of the vapor condenses in the boiler, the uncondensed gas passing over through a pipe, E, into another boiler, F, of about the same size. In each of these boilers a layer of water 6 in. deep is kept, in order to prevent evaporation of the condensed carbon bisulphide. The vapor afterward passes through a leaden coil, G, surrounded by cold water, which is placed in a good sized vessel, so as to present ample condensing surface. This coil is connected to an iron receiver, H, in which a layer of water is kept, with an escape pipe, J, at the top for the waste gases, which consist chiefly of sulphureted hydrogen. At the bottom of the last receiver is a pipe, K, connecting H to the rectifying still, through which the liquid bisulphide is run as it accumulates. The rectifier is immersed in a water bath, and on the application of heat the carbon bisulphide vapor passes over and is condensed by means of an ordinary lead coil cooled by water. The free sulphur remains behind, and is employed again. A glance at the accompanying illustration will make the whole process perfectly intelligible to the reader. Only one retort is shown in the figure; but in actual practice two or more are heated by the same fire, so as to economize fuel. The retorts are cased all round with fire bricks, and the flues, L, reach to within about 4 ft. of the top. At the bottom of the retort is an outlet, M, about 8 in. diameter and 2 ft. in length, with a cast iron flange and cover, which reaches outside the brickwork and is employed for cleaning out the retort. This is done once a fortnight. Above this is a cast iron hopper, N, set in the brickwork, which becomes hot enough to liquefy the sulphur. At the bottom of the hopper is a taper hole, 3 in. diameter, in which a plug, O, fits loosely to allow the liquid sulphur to pass into the retort at the bottom. The retort is filled with dry charcoal to about 3 in. from the outlet, B, at the top, and the lid, P, is then securely fastened. Sulphur is next introduced into the bottom of the retort by means of the hopper at the rate of about 5 lb. every half hour. This is continued for about forty-eight hours, when the retort requires refilling with charcoal. The average yield of carbon bisulphide from each ton of sulphur is from 18 cwt. to 19 cwt.; but, of course, a portion of the sulphur is recovered. One of the largest manufacturers of this article informs me that the yield of carbon bisulphide is fully 10 per cent. less in summer than in winter. This loss he accounts for by the higher temperature which prevails during the summer months. Gas coke is, I believe, always employed as fuel in the manufacture of carbon bisulphide. Regulation of the temperature is a very important point. A temperature midway between dull red and bright red heat is considered the best for the purpose.

In three experiments made by Sidot at different temperatures, using 40 grammes sulphur and 10 grammes purified charcoal, the following results were obtained:

1.	Dull red heat..... ...	5	grm. C	gave 17	grm. C S$_2$
2.	Red heat	6·3	"	" 29	" "
3.	Bright red heat	7·5	"	" 19	" "

These figures prove conclusively that a moderate red heat gives the largest yield of carbon bisulphide, and this temperature should not be exceeded, otherwise there is a risk of the bisulphide being decomposed, carbon being deposited, and free sulphur distilling over. Even when every possible precaution is taken, a certain amount of dissociation always occurs, from 5 to 10 per cent. of sulphur sometimes passing over with the carbon bisulphide, and imparting a yellow color to the crude compound, which requires to be submitted to a process of rectification.

Purification.—The exact nature of the various impurities which impart the offensive smell to crude carbon bisulphide is not properly known, but the odor is most probably due to the presence of complex sulphur compounds. Many attempts have been made to remove these objectionable impurities; but few, if any, have been absolutely successful. The simplest process of rectification, which removes most of the free sulphur, consists in carefully distilling the crude bisulphide from a water bath. Another plan is to wash the impure carbon bisulphide several times with water in order to extract the sulphureted hydrogen, and then leave it in contact with quicklime for some time. The carbon bisulphide is afterward distilled from the lime, and the distillate collected in a vessel containing clean copper turnings. The objectionable smell is said to be removed by these means. The following are some other methods which have been suggested for purifying crude carbon bisulphide: (1) Treatment with permanganate of potash, to be followed by agitation with mercury and careful distillation; (2) repeated distillations with pure oil, which is said to remove some of the impurities each time; (3) treatment with bleaching powder solution, with subsequent distillation. By repeated distillation and chemical treatment, almost pure carbon bisulphide may be obtained, but at so high a price that it cannot be employed for industrial purposes. Attention is now being paid to this point, with a view to prepare the pure article at a moderate cost, and I understand that one large manufacturer is within reasonable distance of success.

Uses.—Once-distilled carbon bisulphide is generally used for recovering oil and grease from waste materials, on account of its low price. It is very impure, and gives off a most offensive smell; but as the oil extraction process is carried on in closed vessels, the escape of vapor is only trifling, and the workmen are therefore but slightly exposed to the injurious action of the bisulphide. By a second distillation, a much purer quality is obtained, the odor not being quite so offensive; and in this state the carbon bisulphide is used, mixed with a small proportion of chloride of sulphur, by India-rubber manufacturers, in the process of vulcanizing rubber goods. Carbon bisulphide is employed for dissolving oil from seeds, and also for extracting the delicate perfume of certain flowers; but for this latter purpose it must of course be exceedingly pure. On account of its poisonous properties, carbon bisulphide is frequently used as an insecticide, more especially in France as a remedy against the phylloxera, which has such an injurious effect upon the vines. It seems probable that diseases of the potato and other crops might be successfully treated in

a similar manner. Meat has been preserved for a considerable time in a closed vessel by the addition of a small quantity of carbon bisulphide, without any appreciable difference in flavor. Owing to the difficulty of freezing carbon bisulphide, it is sometimes employed in making thermometers for measuring exceedingly low temperatures. If a small quantity be added to an electro-plating bath, the silver is deposited with much greater brilliancy. It is also used for dissolving phosphorus in the manufacture of matches. On account of its low boiling point, engineers have endeavored to employ carbon bisulphide for motive power, with a fair amount of success, especially in the case of the Ellis bisulphide auxiliary for reducing the consumption of fuel in steam engines.

Although an industry in which a large amount of capital is not absolutely necessary, the manufacture of carbon bisulphide is in comparatively few hands. The chief element of success is a thorough knowledge of the most favorable conditions of working, particularly as regards the proper temperature.—*Industries.*

ON THE CAUSES OF VARIATION IN ORGANIC FORMS.*

By C. V. RILEY.

LADIES AND GENTLEMEN:

BUT few alternatives are left your vice-president in choosing a subject for this annual occasion. With the modern world-wide activity in biology, to give a review, however condensed, of the progress and discovery of the year, would require far more time than can be given by one who yields to the pleasure and fascination of original research what little time can be snatched from the slavery of official routine and administration. Any such general review, if attempted, could not be critical or authoritative beyond the limits of one's own specialty, and the task is now well done by the combined efforts of a number whose work we get in the German and English records.

"One science only will our genius fit,
So vast is art, so narrow human wit."

To give a similar review of progress in one's own specialty would be to interest but a limited number. I have decided, therefore, to give expression to a few thoughts which have occupied my mind for many years, on the laws of biologic evolution, and particularly on the causes of variation in organic forms. I have been helped to this decision by the appearance, since last we met, of the "Life and Letters" of the immortal Darwin and the loss from among us of the mortal presence of our own beloved Gray. Both men, in their work, gave eminent illustration of the fact that the subjects which I thus take for text may be approached and elucidated from quite different roadways or beginnings. These subjects are, moreover, of still absorbing interest; for we recognize that in evolution is locked up the origin of man, just as in it are involved his present and his future, subjects which, from time immemorial, or from the earliest infancy of the race, have deeply concerned him. The demonstration of the fact, the establishment of the law of organic evolution, have given fresh impetus to inquiry. To know something definite of the past but intensifies our desire to read in that past some prophecy of the future.

Evolution, as a fundamental principle in organic nature, is to-day more thoroughly established and proved in the mind of the average biologist than the Copernican theory itself.

From the time when Aristotle prophetically remarked that "Nature passes so gradually from inanimate to animate things, that from very continuity the boundary between is indistinct," through the suggestive writtings of Lamarck, Erasmus Darwin, Oken, Goethe, Baden Powell, Geoffroy St. Hilaire, Wells, Chambers, Lyell and Spencer, the belief in biologic evolution was growing and expanding, until it ultimately blossomed in the simultaneous labors of Darwin and Wallace.

Prior to the writings of these last it was necessary to fight for the general principle, and long after the appearance of the "Origin of Species" there was a violent clash between the advocates of special creation and those of evolution; so that, much as Darwin felt and cared for natural selection, he was in the beginning more interested in settling the question of "Creation vs. Modification." The fight has continued with ever waning forces on the part of the creationists,† until to-day the evolutionists are victorious and no longer under the necessity of marshaling the facts to bring conviction to the skeptical. Thus biology, the last stronghold of the creationists, has been brought into correspondence with chemistry and physics, in which the opponents of evolution had long before given way. The clearing of the smoke on this last battle field is comparatively so recent that, in the popular mind, evolution yet applies only to the organic kingdom, and it is in this more limited sense that we, as biologists, particularly use the word, and in which I shall use it for the most part in this address. We depend for evidence on an immense number of well ascertained facts, so that the proofs of organic are often stronger than of inorganic evolution. Phylogeny, or the geologic succession of life, as proved by paleontology, finds its correspondence in ontogeny, or the developmental history of the individual, particularly in its embryonic phases; while both find correspondence in taxology, or the relationship of organic forms now existing on our globe. The correspondence, one with the other, of these three great series is one of the most pregnant facts of biology and inexplicable on any other theory than that of derivation. It is the essence of evolution that the present more complex forms are derived from older and simpler forms, and that the greater the difference between groups, the greater the divergence and the deeper down the converging stem or ancestry. We are justified in concluding that complete knowledge (were that possible) would permit us to trace back the origin of every organism to the simple unicellular, ancestral form. I would hardly second the strictures of a former vice president of this section on the "scientific arboriculturists," because philosophy must needs lead from the known to the unknown, and the value of a phyiogenetic table depends on the knowledge and ability displayed in projecting it on the plausibility of those parts which are not based on paleontological facts—and perhaps never can be—but which the facts of embryology suggest. Biologic evolution implies, further, what has hardly been sufficiently emphasized, (1) increase in size or bulk as correlated with the increasing diversity and complexity of organization; (2) that the most highly organized require (comparatively) the longest time for development both in the fœtal and postnatal states; and (3) that large organisms with complex structure are more sensitive to changes of condition and more liable to extinction; and this means that the larger the size and the higher the development, the fewer in number both as to species and specimens.

These principles, now so generally accepted, aside, let us at once throw a *coup d'œil* over some of the factors of evolution and see what we understand of the causes of variation and differentiation, as this is the question of questions among biologists to-day.

The essence of Darwinism as an element in evolution, viz.,† "natural selection," was original with several, and Darwin himself remarks, in his autobiography, that an essay in Hebrew had been published showing that the theory is contained in the Old Testament. He also recognized that Bronn, in his "Geschichte der Nature," forestalled him in many ways. Even as early as 1766 Duchesne wrote profoundly of the lines of variation and evolution, and showed that a genealogical order is the only one which satisfies the mind, all others being arbitrary; and he ventured a genealogical tree based upon profound knowledge and ascertained facts in the natural history and cultivation of the strawberry. The principle was also fully recognized in 1813 by Dr. W. C. Wells, of Charleston, S. C., and in 1831 by Patrick Matthews, as later editions of the "Origin of Species" set forth. Such, however, is the history of all great theories. They cannot be cast at once full-panoplied and impregnable like Minerva from Jove's head. Great discovery is usually more or less definitely foreshadowed.

The publication of the "Origin of Species," however, marked a new epoch in biology, and the work has profoundly influenced modern thought. Yet Darwin's fame rests just as firmly upon that vast structure of facts which he so successfully brought together in his various writings as it does on his theories; and had he never propounded the theory of natural selection, his writings would have immortalized him, for they form an encyclopedia of well arranged data for the naturalist, the agriculturist, and the stock breeder. He threw the light of his genius into recesses formerly obscured, and opened new vistas through old problems which had previously defied elucidation.

It would require volumes even to indicate the extent and character of the literature upon evolution since the appearance of the "Origin." The proceedings of this section of the American Association during a quarter of a century have been, in a measure, typical of the proceedings of like bodies the world over, and constitute a record of the discussions and of the progress of thought and experience in this direction. We have every reason to be proud of the work of American biologists as illustrated in this record; for, notwithstanding the vagaries of a Swallow, and the more able and serious opposition of a Dawson, belief in the derivative origin of species has steadily gained among biologists, and now includes all those whose work and word are worthy of consideration. We may be proud also of the demonstrative proof which members of this section have brought to bear upon the general theory, as also of the newer thought and far reaching generalization original with other members of the section.

In looking over this record, two things strike me as worthy of further consideration. On the one side there has been a disposition to widen the meaning of the term "Natural Selection" so as to include the cause, or causes, as well as the method, of variation and modification. On the other side, the tendency has been to the opposite extreme or to limit the application of the term to the mere selection of the fittest, so that it becomes but the expression of a common and easily observed fact in nature, without involving any of the more fundamental principles of evolution. It becomes merely a means or method and in no sense a cause of modification. Some writers even go so far as to insist that while it is all powerful in originating genera, *i. e.*, in producing adaptive structure, it has little or nothing to do with the production or origination of species, and they would thus render the very title of Darwin's greatest work a misnomer.

It may not prove unprofitable to note what the "Life and Letters" have to say upon this question, and to see what limit, if any, Darwin himself placed upon the term. It is of prime importance that we use it in as accurate a sense as possible, since it has played such an important part in the literature of, and expresses such an important factor in, evolution. The book is most interesting and suggestive; for we not only get from it an insight into the persistent and laborious effort which resulted in Darwin's enduring fame, and left so deep an impression on the scientific work of his generation, but we come to realize how he labored in giving his thought that forceful, logical, yet simple expression which had so much to do in making his work popular; how the candor of his argument and statement was but the reflex of the candor and honesty of his mind. We learn to appreciate more fully the vast range of knowledge he possessed of scientific fact, both from personal experience and authority, and how he bent it to one great end. We come to love him for his many beautiful personal traits; his noble character; his simplicity; the courage with which he bore up under bodily ailment; and for his humanity to animals, which is well brought out by interesting anecdotes given by his son. We honor him for his strong feeling and sympathy with suffering, both in man and beast; for his horror at the suffering of slaves, which inclined him strongly to the Union side in our rebellion, but did not blind him to what, from the average English standpoint, were the political issues at stake; just as his sensitiveness to the suffering of animals did not warp his position on the question of vivisection, which he believed to be justified for investigations in physiology. In scanning the pages of his personal record, we come to realize fully that

"His life was gentle; and the elements
So mixed in him that nature might stand up
And say to all the world—
This was a man!"

But aside from the insight which the book gives into the lovable character of the man, and of his method of work, it is replete with thought and fact, and may be looked upon almost as an appendix to the "Origin." Let us see, therefore, what light it throws on the question we have propounded.

The actual causes of variation may be few or many—remote or immediate; but their discovery or non-discovery no more affects the principle of natural selection than the difficulty in elucidating the causes of gravitation affects it as one of the grandest discoveries and generalizations of our age. We may come to understand, and are already able to elucidate, some of the proximate causes, but the consideration thereof inevitably leads us back farther and farther to the great First Cause, and Darwin's work would never have had so profound an influence had he, instead of basing his theories on demonstrable and experimentive fact, been led into the more speculative realms of causation. Not but that he was intensely interested in the causes of variation; for we have his own words and those of his son to show the ever-present desire in his mind to learn something thereof. But he avoided consideration of them in the same way that he avoided speculation on the origin of life itself, seeing clearly, no doubt, that both questions lead ultimately to Infinite Causation, and that this is beyond man's finite comprehension, in his present state of development, at least.

In a letter to Lyell, September 12, 1860, in response to a question why rodents have not become more highly developed in Australia, he says: "I feel that our ignorance is so profound, why one form is preserved with nearly the same structure, or advances in organization or even retrogrades, or becomes extinct, that I cannot put very great weight on the difficulty." Again, February 23, 1860, he says: "With respect to Bronn's objection that it cannot be shown how life arises, and likewise to a certain extent Asa Gray's remark that natural selection is not a *vera causa*, I was much interested by finding accidentally in Brewster's 'Life of Newton' that Leibnitz objected to the law of gravity because Newton could not tell what gravity itself is. . . . Newton answers by saying that it is philosophical to make out the movements of a clock, though you do not know why the weight descends to the ground."

We may now consider the question of natural selection itself, and see whether, as the expression of a principle, it may not be more strictly defined than it was by Darwin himself.

We find in his correspondence with Wallace that the latter states that the term "survival of the fittest" is the plain expression of a fact. Natural selection, on the contrary, is a metaphorical expression of it, but to a certain degree indirect and incorrect. The great objection which Darwin urged to the term "survival of the fittest" was that it could not be used as a substantive governing a verb, which obliged Spencer himself continually to use the term "natural selection." Darwin recognized, however, the force of the objections to the term, and yet it would be difficult to find a better, and his final preference, after long deliberation and correspondence with men like J. D. Hooker, has justified his judgment. Wallace noticed that Darwin had used the term in two senses: *first*, for the simple preservation of favorable and destruction of unfavorable variations, in which case, according to Wallace, it is equivalent to the "survival of the fittest," and *secondly*, for the effect of the change produced by this preservation. In his autobiography, Darwin says: "But it was clearly evident that neither the action of the surrounding conditions nor the will of the organism (especially in the case of plants) could account for the cases in which organisms of every kind are beautifully adapted to their habits of life." Nothing can be more characteristic than the following in his long letter to Lyell, October 11, 1857: "It has taken me so many years to disabuse my mind of the too great importance of climate—its important influence being so conspicuous, while that of the struggle between creature and creature is so hidden—that I am inclined to swear at the north pole and, as Sydney Smith said, even to speak disrespectfully of the equator." In a letter to Victor Carus we find him inclined to place more value on the definite action of external conditions, and to infer that single variations are of less importance in comparison *with individual* differences than he formerly thought.

I recollect well, while visiting him in the fall of 1871, that he expressed very much the same views which he has expressed in a letter written about that time to Huxley, in which, using the illustration of a pendulum, he says: "The pendulum is now swinging toward our side and I feel positive that it will soon swing the other way." He realized that there would be oscillations in the popularity and general acceptance of his views, and especially as to the part of natural selection as an originating power.

Thus his own views as to the value, scope, and bearing of natural selection varied to some extent, and he used the term in two different senses. In the broader sense, as used by him, and by many of his followers, notably in this country by Fiske, Morse, Marsh, etc., it is a great principle of modification that includes both the fact of variation from whatever cause or causes and the explanation of accumulative divergence along beneficial and adaptive lines. It involves the Malthusian struggle for existence, not only among the organisms themselves, but with the elements and the environment.

It is plain from Darwin's own writings that a term to express the principle was not easily found, and the difficulty was doubtless due to the uncertainty that existed in the author's mind, as it has existed in the minds of his followers, as to the exact limitations of the principle. The term is happy, in my judgment, because it has permitted the focusing of definition by subsequent elucidation. Darwin could but feel that "Wahl der Lebensweise," as a German translation, hardly expressed his opinion, and he was right; "naturliche Zuchtwahl," the later translation adopted, being far preferable.

As propounded by him, natural selection deals essentially with the variation of the individual under like conditions, as distinguished from the variation of the type under change of environment. He impersonates by the term an *ensemble*, *i. e.*, a number of innate conditions of variation. The principle is, in fact, based upon the Leibnitzian axiom "*Natura non agit saltatim*," and it finds a counterpart in the facts of artificial selection induced by man which, in reality, led Darwin to adopt the term to express selection by nature. But here it must distinctly be borne in mind that by nature,

* Address by C. V. Riley, vice-president, section F, before the section of biology, American Association for the Advancement of Science, at the Cleveland meeting, August, 1888.

† The term is used in the theological sense of creation by supra-natural means. Evolution is also creation, but by natural process.

though it is difficult to avoid personifying it, he meant "only the aggregate action and product of many natural laws, and by laws only the ascertained sequence of events. He found it difficult to admit of any personality or designer in any way using natural selection for designed ends, so that the comparison with artificial selection by man lacks in one most important particular; but we may recur to this point later on. Natural selection is a great principle, the promulgation of which revolutionized biology. It is a *modus operandi* of derivative genesis, embodying two somewhat opposing laws, namely, heredity and adaptation; the former for the most part conservative and tending to cause organisms to hold to the past, the latter progressive and tending to cause them to diverge or ramify. It is a *quo modo* of succession, but it implies no necessary tendency to progression, however much such progress may be indicated in the general history of evolution. Certain simple conditions of life may have persisted from before the Silurian age to the present day, and the one primordial prototype of all living and extinct creatures may still exist so far as natural selection is concerned.

It is a principle universal in its action, explaining one important mode of modification and differentiation of forms, especially among higher animals or where the interests of highly endowed or organized beings most strongly interact to give it effect. It must be less effective among lower organisms, where external conditions are evidently prepotent in inducing not only variation, but specific modification. Natural selection, therefore, does not satisfy us as an explanation of the original differentiation of the great classes, and it was perhaps a certain recognition of this fact which caused Darwin to pause on the safe side of their differentiation and not endeavor to explore the deeper mysteries beyond. Yet after all it is among these lowest forms that the key to the explanation of the more important factors in evolution must be sought.

The Darwinian, therefore, who would give fullest expression to the teachings of the master, employs the term in a broad sense as the expression of a principle in nature which explains how the fittest have come to be preserved, and hence the mode of formation of species. The "formation" would have been a happier expression than the "origin" of species, but not so good a catch title, and we should never forget that the sub-title of the immortal work, viz., "The preservation of favored races in the struggle for life," more fully expresses the author's meaning. By its too zealous advocates natural selection has been used to explain phenomena due to other causes. This is, however, a danger that all great discoveries encounter; they are made to do service for which they were not originally propounded. But the opposite tendency, when carried to extreme, is equally unjustified and would obliterate natural selection as a factor in evolution.

Spencer's expression the "survival of the fittest" has often been used as synonymous with natural selection, to the detriment of the latter; for while all must recognize the aptness of the term, as a somewhat tautological expression of the result, it can never be made to cover the principle involved in the Darwinian term. It is an explicit and forceful expression of the fact and in no sense of the theory. Natural selection deals not so much with the survival of the fittest as with the destruction of the unfit. It expresses a cause of differentiation or formation of species and higher groups, in a sense in which the "*survival* of the fittest" does not, however little either term may explain the causes of variation *per se* or the *origin* of the individual variation.

It operates under subjection, taking advantage of variation otherwise initiated; or, to use Spencer's language, it expresses an effect of the mode of co-operation among causes. We are justified, therefore, in saying that natural selection is the essence of Darwinism and is a fundamental principle in organic evolution based on (1) individual variation and (2) the struggle for existence and preservation of the most competent. Other factors of less importance help to give it potency. It is based upon the facts as they may be observed, and the whole superstructure is built upon the innate variability of individuals, irrespective of conditions. The difficulty of getting at the immediate cause or causes of this individual variation led Darwin to consider it promiscuous or aimless, though he wisely avoids calling it lawless. He felt, as we have already seen, that there were causes and that of the majority of these we were ignorant. In his own words, "We can so rarely trace the precise relation between cause and effect, that we are tempted to speak of variations as if they arose spontaneously. We may even call them accidental, but this must be only in the sense in which we may say that the fragment of rock dropped from a height owes its shape to accident."

I have always had a feeling, and it has grown on me with increasing experience, that the weak features of Darwinism and hence of natural selection are his insistence (1) on the necessity of slight modification; (2) on the length of time required for the accumulation of modification; and (3) on the absolute utility of the modified structure. I think that Darwin laid altogether too much stress on these points, and that while, in the main, insistence thereon is justified, a too strict adherence to them weakens natural selection as a true expression of the phenomena of modification. This is particularly true of lower organisms, among which, as we have already seen, natural selection has been and is necessarily less potent than among the more highly organized and complex, from which, especially under domestication, Darwin drew most of his evidence.

Whatever influence we may attach to environment and external conditions, it is self-evident that they alone have not been sufficient to induce the wonderful variety of life existing upon the globe to-day. Indeed, so far as natural selection implies necessary utility, necessary adaptation to surroundings, it is, as I have said, defective.

We know very well that introduced species from one continent to another, or from one country to another, have proved better adapted to the changed conditions than the indigenes or endemic forms. This is readily comprehended on two grounds: *first*, that species which have, in the course of time, experienced a greater struggle among themselves in large areas, have an advantage over those in more limited areas in which the struggle has been less intense; *secondly*, the species which have accommodated themselves to the changes in life conditions which civilized man induces have a great advantage when, following man's migrations, they are brought into competition with species which have not yet been subjected to such conditions. Again, no valid reason can be urged why, within a given area, one species predominates over another in so far as mere adaptation is concerned. The influences of environment alone would tend to unify the fauna and flora of a given region. Theoretically, so far as climate and physical conditions are concerned, there is no reason, through regions where these are uniform, why a single animal should not prevail to the exclusion of all others, provided it was vegetarian, or that the particular plant which furnished food to such an animal should not prevail to the exclusion of all others. The hickory and the blade of grass must be considered equally adapted to the environment with the oak, and so on all through the multifarious forms of both vegetal and animal life: so that this diversity of form can best be explained by some principle like natural selection, and by the interrelation and interaction of organisms and the struggle between them for existence.

This is illustrated in many directions. To take a striking example: no one doubts that if the larger carnivora of Europe and Asia were introduced into Australia, the marsupials would soon have to give way, and could survive only by the acquisition of special functional modifications and larger intelligence, such as we find in our opossum. Yet it would be folly to conclude that the marsupials are less well fitted to the physical conditions which obtain in Australia than their introduced exterminators.

From what has preceded, we are, I think, justified in rejecting the interpretations of both extremists as to the scope and meaning of natural selection. It cannot be debased to the mere expression of the universally observed fact of variability; yet it must be restricted, because it not only implies something to be selected, but its promulgator limits its scope to the selection of something that is useful. As a philosophy it considers only processes and leaves remote origin and cause untouched. The following limitations are probably justified to-day and will help to more exact use of the term:

1. It deals only with individual variation, from whatever cause, and should not be applied to simultaneous variation in masses.

2. It deals only with variations useful to the organism in its struggle for existence, and can exert no power in fixing the endless number of what, from present knowledge, we are obliged to consider fortuitous characters. It cannot perpetuate useless organs; nor those of a vestigiary or obsolescent character.*

Even with these restrictions, the principle is far reaching and profoundly important; but it quite fails to account for many of the most interesting manifestations of life that are obviously not necessary or life preserving, of which many will occur to every one, such as, among lower organisms, many superficial details of structure; or, as among higher organisms, odd habits and customs, playful instincts, ethical traits, etc. Its limitations must be narrowed in proportion as we come to understand the other laws of modification and the causes of variation in masses. Let us briefly consider some of these causes.

While, as already stated, the consideration of this question inevitably leads to Ultimate Cause, there is no more fascinating or profitable field of investigation than that leading to the proximate cause or causes of variation. We are not content to rest the case where Darwin did by recognizing variation as an inherent principle in organic forms, or to beg the question by saying that it is as much a necessity of life as natural selection itself. Let us, therefore, discuss these causes in the light of recent experience and experiment.

We soon find that they admit of a certain amount of classification, the minor divisions of which, as in all systems of classification, more or less fully interlock or blend. They fall, however, into two chief categories, viz., (1) external conditions or environment, which are, at bottom, physical, and (2) internal tendencies or promptings, which are, at bottom, psychical. We shall also realize more fully that there is good reason for the varying importance which has been placed on natural selection because it represents a broad principle, based on the outcome of both these categories, but particularly of the latter. Its value is not a fixed one, and must needs change with the increase of exact knowledge of the other factors, and did in fact change in the mind of its originator. We shall further find that there are laws of evolution which permit of formulation and expression, and which have influenced or controlled the mode of variation, but which must not be confounded with or included among the causes of the variation proper, though here again the line between the two kinds of factors is not always easily defined.

The conditions of organic modification may, therefore, roughly be classed as (A) external and (B) internal, and these may be almost indefinitely subdivided. The former class includes (1) *physical* and (2) *chemical* forces, and in a broad way may be said to induce modification independently of natural selection, however much this may act with them as a secondary cause. Certain prominent features of the physical forces are worthy of mention: as light, temperature, water (stagnant, or in motion), climate (under which term may be included meteorologic phenomena, as electricity, atmospheric pressure, etc.), mechanics (gravitation, wind, stress, friction, etc.) and geographics (migration, isolation, etc). The chemical forces may be considered under the subdivisions, aquatic, atmospheric, food, and soil. In class A may also be included (3) *vital*† or organic force in so far as this is concerned with the interaction of organisms, and it is seen thus to link the two great classes. The second class (B) includes (1) *physiological* and (2) *psychical* forces. Prominent among the former, as causes of modification, are worthy of mention those connected with genesis itself; as heredity, physiological selection, sexual selection, hybridity, primogenital selection, and what I would call sexual differentiation, and philoprogeneity. Among the latter may be included use and disuse, individual effort, etc.; and last, but not least, the emotions.

* In the literature of evolution, these are usually termed rudimentary, but strictly speaking this term should be applied only to nascent or incipient structures.

† I am well aware that this term is much tabooed among a certain class of the more materialistic evolutionists, but I use it here for want of a better, and because as an expression of one form of manifestation of force it has as much a classificatory value as physical or psychical.

As already stated, any such classification of the forces at work in organic evolution must be more or less arbitrary and artificial. Fundamentally, also, they are, perhaps, convertible terms—unifiable—one. But some such arrangement as that here suggested serves to simplify discussion.

Now, with the limited definition given to natural selection, all the forces in class A act independently of it, while the rest are more or less fully aids to its action. Time will not permit of much detailed consideration of the physical and chemical forces. Nor is such consideration necessary; for their influence, as Darwin well remarked, is obvious. Fundamentally, they must needs limit and control all manifestations of life of which indeed, on evolutional grounds, they are the material basis.

Change of physical environment may affect function first and chiefly, but this involves change of form and structure which are integrated by heredity. The surface of the earth and the waters upon it and the atmosphere above it have necessarily conditioned the chief modes of animal locomotion as swimming, flying, crawling, and walking, while the five great classes of vertebrates find the explanation of their structure, as J. B. Steere pointed out at the Ann Arbor meeting, in the conditions of life in water, in shallows, in the air, on land, and on trees and rocks.

(*To be continued.*)

UNITED STATES EXHIBIT AT THE BARCELONA EXPOSITION.

THE section pertaining to the great republic is worthy of notice, not only on account of its importance, but also by reason of the good taste which has been exercised in the harmonic arrangement of the exhibits, due principally to the genius and activity of its worthy commissioner, Mr. Emilio M. Blum, seconded by the able commission which governs.

In these grand concourses, in which, as a general rule, each exhibitor arranges his objects according to his caprice, or that of the artist to whom he intrusts his installations, a want of harmony is usually seen. But on entering the American nave we perceive at once that an able direction has had charge of affairs, that a most adequate design has been prepared, not only in respect to the installations which are presented, but even to the smallest details of decorations. All the United States exhibitors united in giving to their commissioner (Mr. Blum) the most ample facilities for everything, and in this way he has been able to arrange the installations without obstacles of any kind.

In respect to the artistic part, he gave instructions to the well known painter, Mr. Padro, who has known how to interpret them.

If a visitor stands on the rise which forms the vestibule of the commission saloon, at one of the entrances, he completely overlooks the beautiful perspective which the nave presents. On the walls which inclose the exhibits are displayed white stars on a background of dark blue. Upon this ground are enormous shields with the initials of the United States emblazoned thereon, and further adorned with large American flags. Below these shields are imitation parchment scrolls with inscriptions upon them, forming a continued line of festoons along the whole extent of the side walls, upon which we read the names of illustrious Americans; below these hang bands extending across the whole width of the nave, which present in golden letters upon a dark red background the names of the great cities of the republic. The combination of the flags, the backgrounds, the shields, the names, and the festoons results in producing the appearance of an enormous arch, which presents a striking effect.

Next to the wall on the left, in the middle of the nave, there stands, dominating over all, a gigantic statue, the reproduction of "Liberty enlightening the World," which is erected in the bay of New York. A worthy matching of this statue upon the wall in front is an allegorical picture of colossal dimensions, as well conceived as executed. It represents Spain extending her hand to the United States. At her feet is a pediment bearing the motto "Non plus ultra." The figure of Spain is represented by a matron with the royal crown, holding the red and yellow flag, and a young female figure represents the North American nation, with the attributes of the republic. In the upper part of the picture Genius appears, crowning the forehead of Columbus with a crown of laurel.

Upon the opposite front of the part occupied by the commission, the whole wall (which is about 80 feet in width) is occupied by an immense map of the United States. As a vignette there is an eagle, with wings extended toward the sun, and holding in its talons the shield of the republic. This map serves as a background to a group of sculpture, also of gigantic size, which arrests the attention. Upon a simple pedestal of stone a female figure—the image of the republic—is seated, the left hand resting upon the table of the law, the right hand holding aloft the sword of justice. Her temples are bound with a diadem of stars, representing the thirteen original States of the nation. At the right of this statue is that of Liberty, and at the left that of Progress.

This notable group of sculpture is produced in bronze, in the Pompeiian style, and the pediment upon which it is placed is an imitation of jasperized marble of dark gray color, whereon in golden letters we read appropriate inscriptions and symbols.

At one side, and between the columns, we have views of the great cataract of Niagara, Brooklyn Bridge, the Capitol at Washington, the enormous tree of California, through whose trunk passes a highway, etc. The portraits of Washington and Cleveland figure as presiding over the nave, under a shield with which are entwined the Spanish and American flags.

The two saloons which constitute the headquarters of the commission are splendidly adorned, and between their two doors is a grand mirror which reflects the whole nave.

Among the many installations are some very notable and worthy of mention, of which we name the following: Two tramway cars, as spacious as elegant, one of them built by J. G. Brill Co., the other by John Stephenson Co., a mechanical drill for perforating rocks, varnishes by David B. Crockett Co., a flour mill from Birmingham, machines to wash and dry clothes by Recknagel & Co., a superb installation of sewing machines by Singer, pianos and harmoniums from the Sterling Co., which

FROM A PHOTOGRAPH.

THE UNIVERSAL EXPOSITION OF BARCELONA.—THE UNITED STATES SECTION IN THE PALACE OF INDUSTRY.
FROM A PHOTOGRAPH.

are distinguished by certain novelty in the forms, agricultural machines and apparatus by Walter A. Wood Mowing and Reaping Machine Co. and by Higganum Manufacturing Co., oleographs and chromos by L. Prang & Co., among which are admirable specimens of flowers, lamps for gas and petroleum from the Ansonia Brass and Copper Co. (these lamps are very perfect, and require no chimneys or shades); mechanical carpet sweepers from Bissell Carpet Sweeper Co.; apparatus invented by Edison for the reproduction of manuscripts; cigars and manufactured tobacco from Allen & Ginter and J. C. Dowell & Co.; preserved meats, fruits and vegetables by Kemp, Day & Co; Continental beer by Breurin Co.; Dr. Ayer's specifics; casks, vats, etc., constructed of wooden fiber by the Union Indurated Fiber Co.; iron safes by Herring & Co.; alarm bells, dentists' materials, most beautiful floor tiles with ornaments in relief; various articles forged in iron; magnificent axes and spades, and finally, a curiosity consisting of hollow canes filled with cigars.

For the above particulars and for our engraving we are indebted to *La Ilustracion Española*.

THE LABOR QUESTION IN HOLLAND.

THE German *Archiv fur Soctale Gesetzgeburng*, etc., discussing the preliminary reports of the parliamentary commission appointed last year by the Dutch chamber to inquire into the condition of the laboring classes in Holland, gives some interesting facts relating to this subject. Holland is essentially a country of small industries, in which industry on a large scale is only slowly advancing. Having no coal or raw materials of its own, and no heavy protective duties, the manufacturers are able to meet foreign competition only by utilizing to the utmost badly paid labor.

The smaller master bakers of Amsterdam, for instance, in order to compete with the machine-made bread of wealthier bakers, work 16 hours a day all the week, except on Fridays and Saturdays, when they work for 26 hours without intermission. The 5,000 tailors of the same city try to compete with the large firm Van der Waal, which employs machinery worked by women and girls, by working with their wives and children till midnight, and sometimes 24 and even 48 hours on end. Day and night work prevails in Dutch bakeries, steam mills, breweries, vinegar factories, sugar refineries, and the gas, glass, paper, and many other industries.

The work is done in shifts or relays, so that the man who works during the day one week works during the night the following week, and if men are ill or away others who have already worked must take their places, so that extremely long hours—18, 24, and 36 hours are mentioned—are common. The average day in the great majority of the factories is 13 to 14 hours. In one province in which complete statistics were obtained it was found that 39 per cent. of the total number of workpeople was composed of women and children, and the number everywhere is constantly increasing. The only factory law of Holland prohibits the employment of children under 12, but there is no system of adequate inspection, and children, in fact, work as long as the adults, as well as in dangerous and unhealthy trades. The effects of women and children labor on the rising generation are exhibited in various ways.

Infant mortality in all Holland increased 19 per cent. between 1880 and 1885, while in Maastricht the increase was 21, Eindhoven 30, and Gouda 33 per cent. Wages are much lower than in other countries, and do not keep pace with the increase in the cost of living. Working ten hours a day, and with constant employment, the Dutch workman may earn £37 10s. a year. The commission states that the low wages and long hours have not really been of advantage to Dutch industry; technical improvements are neglected, and the inventiveness of workmen is destroyed. The following are the principal recommendations of the commissioners: Efficient factory inspection, enforcing the law against children's labor, prohibition of night and Sunday labor for women and children, and provision for securing adequate rest for them, and prohibition of female labor for a month after confinement.—*London Times.*

THE CORAL INDUSTRY OF LEGHORN.

THE French consul at Leghorn in a recent report states that the coral industry has long flourished in Italy, its chief centers being Naples, Genoa, and Leghorn, but in recent years it has been declining. The price, which in 1883 was 800f. per kilogramme for wrought coral, fell to 600f. in 1884, 400f. in 1885, and was down to 200f. in 1886 and 1887. The export from Leghorn, which was valued at 11,298,400f. in 1883, amounted only to 3,104,600f. in 1886, while in quantity the exports increased in these years by 10 per cent. There was a little improvement in 1887, but this is not believed to have been permanent. The great fall in price, which is ruining the industry in Leghorn, is attributed to the large supplies which come from Sciacca, in Sicily, and it is believed that these are due to some kind of submarine disturbance having put the coral where it is now obtained. Raw coral of medium quality has fallen in price from 10f. per kilogramme to three, and even less. The consul himself saw poor Sciacca coral sold for 50 centimes the kilogramme. Ten years ago this would have cost about 8f.

The most flourishing year for the coral industry was 1880, when the Sciacca reef was discovered. The greater part of the coral manufactured in Leghorn is sent to Russian Poland, Finland, Russia, the Balkan Peninsula, Asia, and Africa. From the most ancient times every country has had its favorite shapes. In spite of the universal fall in prices, the best worked coral is still dear. A perfect piece of dark color, about the size of a pigeon's egg, is still worth 800f. to 1,000f.; ten years ago it would have cost 1,600f. to 1,800f. Special pieces such as this are chiefly used to decorate the caps of mandarins or the turbans of wealthy Mussulmans. The red, whitish, and generally the light colors are less prized than the dark ones.

The export to some countries has declined, because coral is now less used for money than it was, but still considerable quantities are sent to Abyssinia, the Congo, India, Ceylon, the Cape, Siberia, Japan, and China. The merchants themselves cannot tell how coral is used in all these countries. It is believed that it is used to decorate arrows, lances, etc., and also that the bodies of important persons are adorned with it after death. Peasants in Central Italy at one time used it to ornament their persons, because they knew that it could easily be turned into money when necessary; but now they do not buy it with this idea, since the fall in prices has been so great. Many houses in Leghorn in the trade are already shut up. Ten thousand women were employed in the industry, nearly all of whom work at home; the number now is about half of this. Yet nearly double the quantity is now exported than in 1882, but it is of inferior quality, and receives less hand work. No machines are used, nor are there any mechanical processes in connection with the manufacture. The women give the required forms to the pieces by hand. The women get from 7d. to 15d. per day. In Europe coral is in little demand; it seems to have a special suitability for barbarous and semi-civilized peoples.

A HORNED SNAKE.

ON Sunday, Sept. 23, as Meade F. White, Esq., was returning to Staunton from Highland County, he killed, near the top of Shenandoah Mountain, what is known as a horned snake, which measured five feet and seven inches in length. He brought it to Staunton, where it was examined by many persons. Its colors are black and pale yellow, and is marked somewhat like a rattlesnake. The tail terminates in a small bifurcated point, from which it ejects a sting, which is supposed to be poisonous. Mr. White says that when it was alive, he saw it eject the sting. If venomous, it is a dangerous snake, as it can strike with either end. They are very rare and seldom seen.—*Staunton, Va., Spectator.*

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